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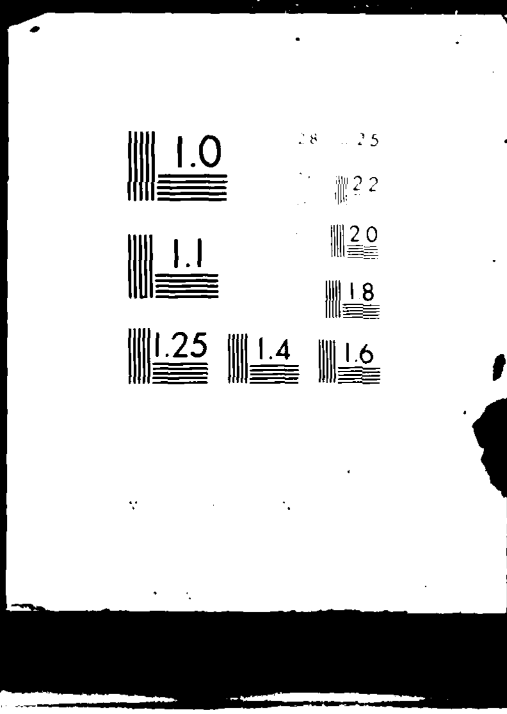

EXECUTIVE SUMMARY

August, 1981

The Final Report of the New England River Basins Commission's Hydropower Expansion Study

Water, Watts, and Wilds

Hydropower and Competing Uses in New England

81

ERRATA

WATER, WATTS, & WILDS
NERBC August 18, 1981

p. 29: Table 2-5, PURPA Rates in New England
The rate for Rhode Island should be 70-85 mills/kwh.

p. 86: Fig. 6-4, Hydrograph Showing Instream Flow Needs for Indigenous Fish
The wording within the graph should read Median August Flow, not Medium August Flow.

p. 122: Appendix C, Recreational and Scenic River Data
The following river segment should be added to the Massachusetts listing:

Deerfield	Scenic: Charlemont to Connecticut R. White Water: Below Bear Swamp Dam to Charlemont	Scenic: X Historic: X WW Canoeing: X Class II: X When Runnable: April Flow Needed: 1000-1500cfs Usage: High Narrative: High level of recreational interest. Strong local concern and protection interest. Hoosac Tunnel-historic. Several dams already exist on this stretch.

p. 129: Appendix C, Recreational and Scenic River Data
Pawtucket River should read Pawcatuck River.

p. 134: Appendix E: FERC Licensing Process, LICENSES, in paragraphs 2 and 3, 5 Mw should read 1.5 Mw.

EXEMPTIONS, delete "and operate in a run-of-river mode" from the second sentence of the second paragraph of this section.

(11) Aug 81

Water, Watts, and Wilds

Hydropower and Competing Uses in New England.

(9) The Final Report of the New England River Basins Commission's Hydropower Expansion Study August, 1981

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The following contractors also provided invaluable assistance on various aspects of the study: International Engineering Co., Inc. (analysis of economic and engineering issues relevant to minimum flow requirements); Barry Lawson, Associates, Inc., (Workshop design); Resource Policy Center, Dartmouth College (Computer programming and data management); the U.S. Army Corps of Engineers, New England Division (Dam inventory and feasibility methodology); Peter Corbett (Editing); and Booth Simpson Designers, Inc. (Layout and design).

NERBC New England River Basins Commission

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July 20, 1981

MEMORANDUM

To: The Citizens of New England

From: CDR. Stephen L. Richmond, Alternate Chairman SLR

Subject: Water, Watts, and Wilds: Hydropower and Competing Uses in New England

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I am pleased to present NERBC's final report on hydropower expansion in New England. This report is a compendium of findings covering the feasibility of developing hydropower at over 11,000 existing and new dam sites in New England. The report describes the potential for hydropower development and the types of problems that may result from competition between hydro development and other uses of New England's rivers. Alternatives to mitigate conflicts between hydropower and competing uses are also addressed.

A product of over three years of work, the report was prepared with the help of hundreds of public participants, all six New England states and several federal agencies serving the region. NERBC's hydropower staff merit special mention for the quality of their work and their tireless efforts to complete this challenging project.

Because of budget trimming actions by the Reagan Administration, NERBC will no longer exist as a Title II (P.L.89-80) commission after September 30 of this year. Formal review and adoption procedures customarily followed for major NERBC studies have been waived in order to issue this report prior to the close of business. For this reason, the report is being issued as a technical document without formal recommendations for changes in policy or action by federal and state agencies.

The circumstances of its release should in no way diminish the value of this report. The information and thoughtful analyses contained herein should assist developers, regulators, and the public alike, in the difficult process of developing New England's hydropower capacity.

Acknowledgements

Throughout the course of this study, a Study Management Team met on a bi-monthly basis to provide the staff of the New England River Basins Commission with technical advice on the study's scope, methodology, and findings. The assistance of this task force is greatly appreciated. Members of the task force included representatives from the following agencies or organizations:

Federal Energy Regulatory Commission
U.S. Army Corps of Engineers, New England Division
U.S. Department of Agriculture, Soil Conservation Service
U.S. Department of Interior
  Environmental Review Officer
  Heritage, Conservation, and Recreation Service
  Fish and Wildlife Service
U.S. Environmental Protection Agency
U.S. Geological Survey

Connecticut Office of Policy and Management, Energy Division
Connecticut Department of Environmental Protection
Maine Office of Energy Resources
Maine Department of Environmental Protection, Bureau of Land Quality Control
Massachusetts Office of Energy Resources
Massachusetts Department of Environmental Management
New Hampshire Water Resources Board
Rhode Island Governor's Energy Office
Rhode Island Department of Environmental Management
Vermont Public Service Board
Vermont State Planning Office

Energy Law Institute, Franklin Pierce Law Center
Public Service Co. of New Hampshire
Resource Policy Center, Dartmouth College

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Executive Summary

This report concludes a three year Hydropower Expansion Study conducted by the New England River Basins Commission. Basic objectives of the study were:

- to assess the feasibility of developing hydropower facilities at existing dams and undeveloped sites throughout the New England region;
- to clarify competing use issues which arise from the competition between hydropower development and other uses of water resources, and to assess the likelihood that conflicts would arise from such competition; and
- to provide information and data which will facilitate either the avoidance or resolution of competing use conflicts.

Key findings from the study are summarized, ~~below~~.

The Development of Hydropower and Its Effects on the Energy Security and Economy of New England

NERBC has identified 320 existing or breached dam sites in New England which could be retrofitted to generate hydroelectricity at an estimated cost of 125 mills ($.125) per kilowatt hour or less. These sites are the most economically attractive sites screened from an inventory of over 10,000 dams throughout the six state region. They were analyzed using a generalized computer model, which assumed site development would be privately financed at an interest rate of fifteen percent. Selection of the 125 mills/kwh threshold was done somewhat arbitrarily to identify a discrete set of the most feasible sites in the region. For comparison, public utility commissions in the six New England states estimate the current avoided cost value of energy generated by small scale hydro to be between 60 and 90 mills per kilowatt hour. The total generating capacity which could be developed at these 320 sites ranges from 300 to 600 megawatts.

NERBC also identified 44 sites at which no dams currently exist where power could be generated for an estimated cost of 115 mills per kilowatt hour or less. This estimate of generating cost does not include the cost of transmission lines, and again assumes that private financing for development would be available at an interest rate of 15%. The total generating capacity which could be developed at these 44 sites ranges from 270 to 475 megawatts.

Approximately 60% of the electricity produced in New England in 1980 was generated at oil-fired plants; the generation of this power required about 78,000,000 barrels of oil. Hydropower currently contributes between 4% and 6% of the electricity generated annually in the region.

If all of the 320 existing and breached dams that ranked most favorably in the NERBC analysis were retrofitted with power plants, they could generate about 2,000,000 megawatt hours, providing an additional oil savings of 3.5 million barrels or about 4.5% of current consumption. Development of hydroelectric facilities at the 44 sites most promising for new dams could provide an additional 1,700,000 megawatt hours annually, for a further savings of 3.5% of current consumption. Since it is unlikely that all of these 364 sites will be developed, the total oil savings which will actually result from the development of hydropower is likely to be 3% to 5% of current consumption. Although this may seem to be a somewhat limited contribution to the energy security of New England, the development of hydropower, particularly in conjunction with conservation measures and the development of other alternative energy sources, will help to improve the energy situation in the region.

Electric rates are based on the costs of providing electrical service from all generating plants (nuclear, oil, coal, etc.) in a system. Since hydro will make a limited contribution to the overall generating capacity of the region, the development of hydro will not significantly reduce electric rates for consumers. Furthermore, as a result of the Public Utility Regulatory Policies Act (PURPA) enacted in 1978, the price utilities pay for hydroelectricity generated by private developers will essentially be based on what the utility would have to pay to produce the same amount of power using alternative means, primarily oil-fired generation in New England. As the price of oil continues to rise, the cost of hydroelectricity also will rise. Thus, while this pricing mechanism is likely to stimulate substantial investment in hydropower for the purpose of improving our energy security, there is likely to be little benefit to consumers in the form of rate relief in the near future.

Development of hydropower at the approximately 350 existing and new dam sites could produce 6,000 to 11,000 short-term jobs in the region, based on a peak project employment average of about ten workers for each megawatt of capacity developed. Total wages for construction are estimated to be between $106 to $200 million. Additional income will be generated in surrounding communities by the spending of workers at hydro sites.

Potential tax revenues for local governments in New England are estimated to be approximately $19 million to $27 million annually, based on a regionwide average effective tax rate of roughly 2%. Hydropower facilities thus may provide some benefits in the form of increased tax revenues to local governments throughout the region.

The combined effects of investment tax credits, a guaranteed market for small scale hydropower, and a sale price per kilowatt hour linked to the cost of oil have stimulated substantial interest in hydro development in New England. As of May 1981, the Federal Energy Regulatory Commission (FERC) had received more than 250 applications for exemptions, preliminary permits, or licenses. About 70% of the applications are from private developers. 80% of the projects involve the retrofitting of existing or breached dams, 73% would have a head less than 50 feet, and 80% would have an installed capacity less than five megawatts. The aggregate capacity potentially available from these sites exceeds 950 megawatts, although further analysis may determine that development of some of this capacity may not be feasible.

Conflicts between Hydropower and Other Uses of Water Resources

The operation of retrofitted, existing dams *in a run-of-river mode* will pose few conflicts with other uses of New England's rivers and streams, providing the facilities do not involve significant diversions of stream flow. Rehabilitation of breached dams or construction of new dams will result in the creation of new impoundments, and may cause conflicts with competing uses. Store-and-release operations will conflict with competing uses that depend on pre-existing patterns of lake level fluctuation or downstream flow.

As noted above, most of the proposed projects in the region involve retrofitting of existing dams. However, of the 162 projects for which data is available, only 23% would involve installation of a power plant at the dam, while 26% would involve diversions of stream flow of 1 to 300 feet, 22% would involve diversions of 300 to 1,000 feet, and 29% would involve diversions of greater than 1,000 feet. Thus, depending on the extent to which the streams immediately below these dams are important for other flow-related uses, there is substantial likelihood that retrofitting of existing dams will cause conflicts with competing uses.

Competing uses in New England with which hydropower facilities are most likely to conflict include anadromous fisheries, and inland, cold water fisheries. 26% of the existing dams, 34% of the breached dams, and 41% of the new dam sites identified by NERBC as most feasible for development are located either on existing anadromous fish runs or on runs currently under restoration. Conflicts with inland cold water fisheries deemed most significant by sporting groups may occur at about a quarter of the existing sites and at half of the new dam sites.

Effects on lakeshore development and recreation caused by changes in the fluctuation of water levels after installation of hydropower facilities are cited frequently as potential problems, although there is little data available on this issue. Of the existing dam sites studied by NERBC, only 10% were found to be located on or immediately above river segments valued for white-water recreation. Potential conflicts between new dam development and white water recreation were found to be more widespread, however, as were potential conflicts with protection of scenic river segments.

Data developed by NERBC for the purposes of identifying potential conflicts is aggregated and displayed in Figure ES-1 for each of the New

England states and in Figures ES-2 and ES-3 for each of twenty major river basins in the region. These bar graphs show the amount of conflict with one or more of four competing uses: anadromous fisheries, significant freshwater fisheries, river recreation, and protection of scenic quality.

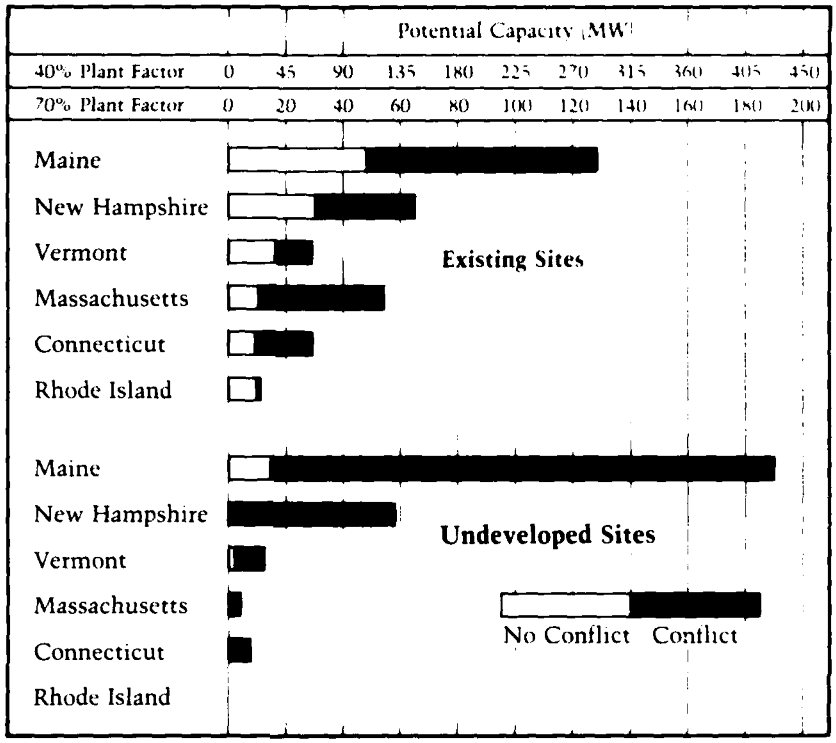
With respect to these four uses, specific findings include the following:*

- Approximately 40% of the aggregate capacity potentially available at the 364 sites studied can be developed without substantial conflict;
- Certain basins which appear to have potential only for retrofitting of existing dams may be developable over almost their entire length without significant conflict. Examples include the Blackstone, Pawtuxet, and Thames;
- The basins with greatest potential for hydro development at existing dams - the Merrimack, Connecticut, Androscoggin, and Kennebec appear to have a number of locations on tributary rivers at which the development of hydropower facilities will not compete with fisheries, recreation, or scenic uses and values;
- Proposals which call for substantial diversion or regulation of stream flow will cause considerable problems with competing uses on certain rivers; examples of rivers where controversy has already developed include the Farmington in Connecticut, the Pawcatuck in Rhode Island, and segments of the Androscoggin in New Hampshire;
- The development of new dams is likely to cause significant conflicts, particularly if pursued on reaches of the Kennebec and Dead Rivers near their confluence in Maine, on the East and West branches of the Penobscot in Maine, on the White River in Vermont, and on the Deerfield in Massachusetts.

The findings noted above are based solely on a correlation of the locations of the hydro facilities deemed most feasible by NERBC with the locations of significant competing uses identified by either state and federal agencies or by particular interest groups. Identification of potential conflicts did not take into account variations in project design and operating mode, nor were the mitigating effects of measures such as the maintenance of adequate flow releases or the provision of fishways considered.

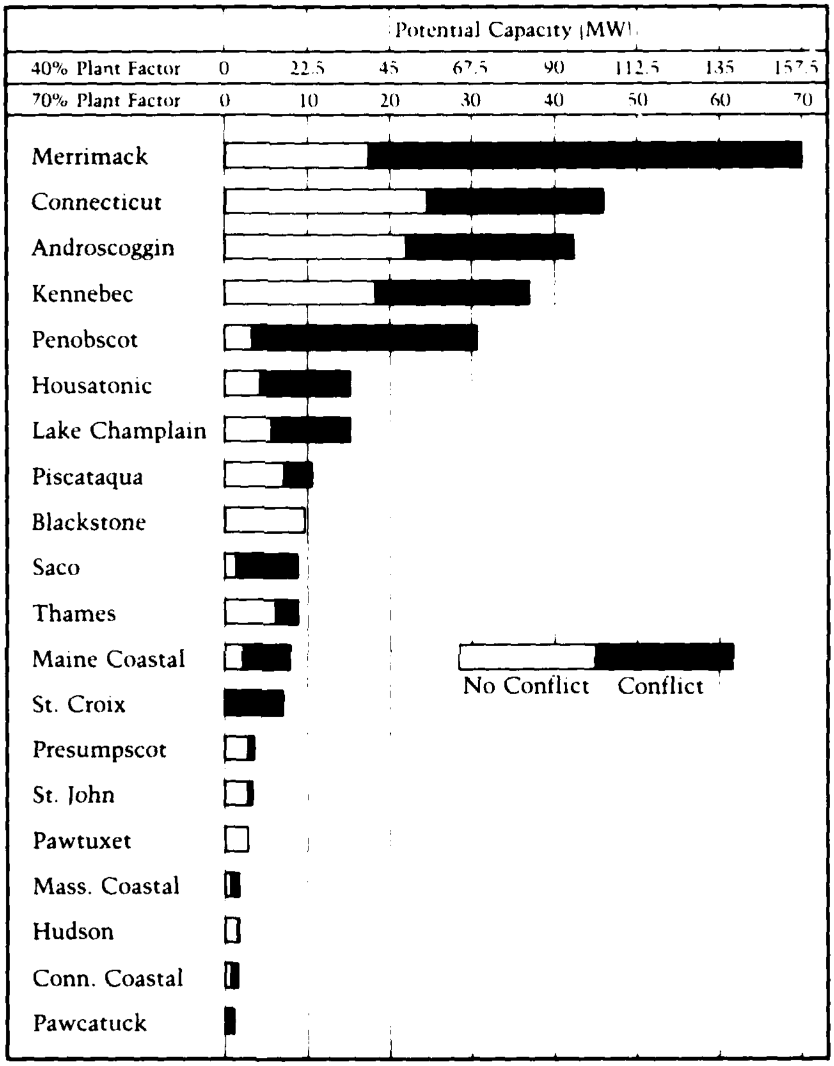
Furthermore, not every impact of hydro development is necessarily negative. For example, regulation of streamflow by hydropower installations may lengthen the season during which canoeing or white water rafting is possible on certain rivers. Hydropower projects can be designed to include features which increase access to the water for recreational purposes, such as canoe portages or launching ramps. Fishways can be

* Note: The reader is referred to the maps accompanying this report for a more precise definition of the basins or river segments cited here.



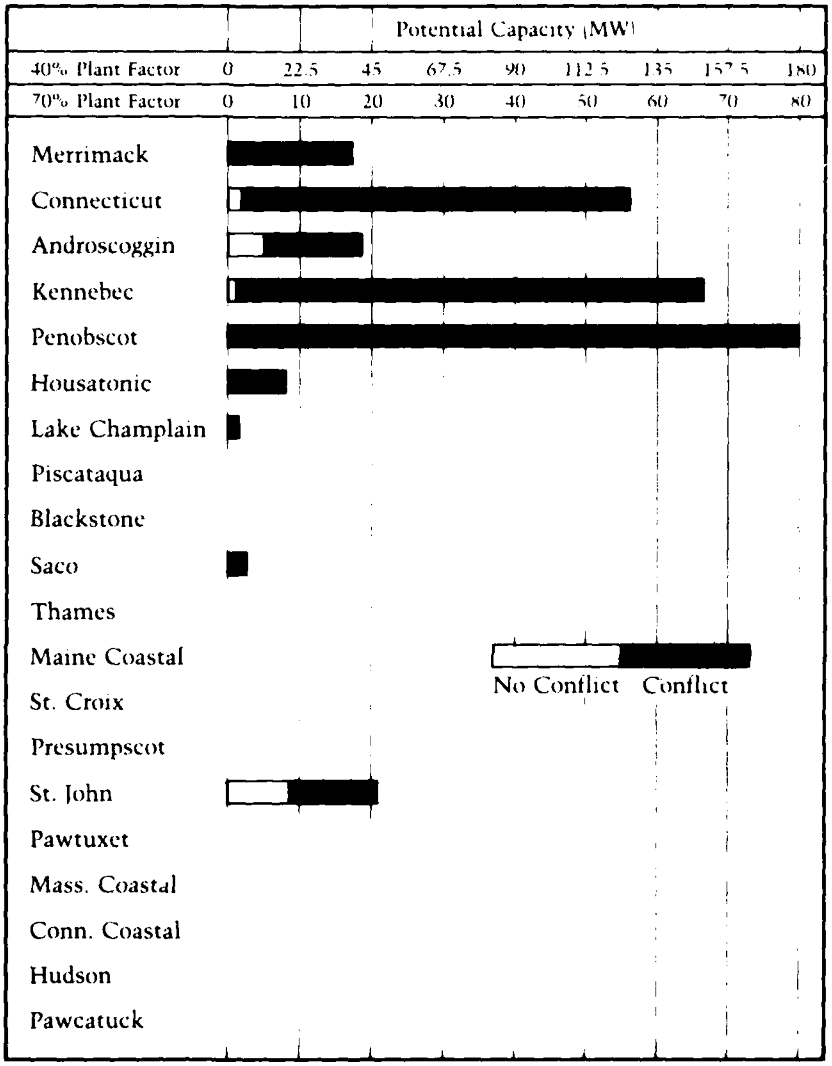
Note: Potential conflicts include potential conflicts between hydropower development and anadromous fisheries, significant cold water fisheries, recreation, or scenic area preservation.

Figure ES-1: Distribution of Potential Conflicts



Note: Potential conflicts include potential conflicts between hydropower development and anadromous fisheries, significant cold water fisheries, recreation, or scenic area preservation.

Figure ES-2: Distribution of Potential Conflicts at Existing Dams in Major New England River Basins



Note: Potential conflicts include potential conflicts between hydropower development and anadromous fisheries, significant cold water fisheries, recreation, or scenic area preservation.

Figure ES-3: Distribution of Potential Conflicts at Undeveloped Sites in Major New England River Basins

installed to provide fish passage where none previously existed. Retrofitting of existing dams might enhance the restoration of historic structures such as powerhouses and dams. The creation of new reservoirs by the construction of new dams or the repair of breached dams may be desirable in urbanized areas or in places where there is demand for lake recreation such as motorboating or swimming.

Resolving and Avoiding Conflicts

The body of laws and administrative procedures governing hydropower licensing reflects the need to reconcile the development of hydroelectric facilities with other flow dependent uses. The licensing procedure established by the Federal Power Act (FPA) and administered by the Federal Energy Regulatory Commission (FERC) regulates the construction, operation, and maintenance of hydroelectric projects. Section 10A of the Act establishes a clear policy for reconciling hydropower with other river dependent uses and interests:

> *. . . the project adopted . . . will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of water power development, and for other beneficial public uses, including recreational purposes . . . ;*

This general policy is supplemented by other sections of the Act which require explicit consideration of the effects of a project on recreation, fisheries, and navigation, as well as on related interstate commerce.

The FPA is the primary law governing hydropower. It vests FERC with the authority to override state statutes and policies in the licensing process. In some cases, other federal statutes are also subordinated to the jurisdiction of the FERC, although this issue is the subject of considerable legal debate. As a matter of practice, however, prospective developers are required by FERC to consult with other agencies to demonstrate compliance with state and federal statutes governing water quality, recreation, fisheries, and other aspects of water resources. This practice has been sanctioned by action of the courts.

The principal means for resolving conflicts between hydropower and competing uses will often be the negotiation of schedules of *instream flow releases*. Maintenance of adequate releases can minimize adverse effects on waste assimilation, fisheries and recreational use, and can protect the scenic values in river reaches downstream from hydropower projects.

With the recent advances that have been made in the design and manufacture of small, packaged power plant units, it appears that the feasibility for accomodating minimum flow releases in the design and operation of hydropower projects is quite good. In an analysis of thirteen case study sites conducted by NERBC, for example, it was found that use of small turbines to generate electricity from minimum flow releases can substantially reduce the adverse economic effects of minimum flow requirements on hydropower feasibility. (The sites studied were generally representative of the types of projects now being proposed in the region and typically involved a diversion structure with the main powerhouse located downstream from the dam.) Maintenance of minimum flow releases unquestionably reduces annual energy output. However, the reductions may be justified if a balance among the flow needs of competing uses is considered desireable and consistent with public policy broader than that applicable only to the promotion of hydropower development.

Fish passage facilities are another principle means of resolving the conflicts which arise from the development of hydropower. As many as one-fourth of the region's most promising hydropower sites are located on existing anadromous fish runs or runs currently under restoration. Some form of fish passage facilities are likely to be required at these sites.

Fish passage costs are highly site specific. At $8,000 to $12,000 per foot of head, however, they will make up a large percentage of project costs (9-10%) on smaller projects at existing dams where there is limited flow relative to the available head that must be utilized to generate economically feasible power. Requirements for fishways on such projects may render the project economically infeasible, and thus make impossible both the generation of hydroelectric power and the restoration of fish passage. To insure that these objectives are achieved, some form of public subsidy may be appropriate at those dams where economic feasibility is marginal and where hydroelectric generation and restoration of fisheries would be compatible, keeping in mind that tax credits are already available for investments in fishway facilities.

For new or breached dams located on rivers or streams significant for anadromous fisheries, the costs of constructing fish passage facilities unquestionably should lie with the project applicant, since in these situations, construction or reconstruction of the dams will pose barriers to fish migration that do not currently exist.

Avoiding conflicts altogether seems possible at many sites which are desirable for hydropower development. The retrofitting of existing dams causes fewer conflicts between hydropower and competing uses than does the construction of new dams or the repair of breached dams. Since there are a great number of existing dams in New England, interested developers have many opportunities to locate hydropower facilities at sites at which conflicts with other uses are likely to be minimal. In addition, design and operation of hydro facilities at existing dams which minimize the need for diversion or regulation of stream flow will reduce the likelihood of conflict even on streams which are intensively used for other purposes.

The maps provided by NERBC in conjunction with this report are intended to facilitate the process of identifying sites with minimal potential for conflict. Significant fishery, recreation, and scenic resources have been indicated in order to make it possible to identify stream segments which are valuable for uses other than hydropower. The identification of these segments is based either on established agency priorities for resource management (e.g., protection of anadromous fisheries) or the consensus of various constituency groups who have a strong interest in the use and protection of certain water-related resources (e.g., inland cold water fisheries, recreation segments, and scenic reaches).

Prospective developers can substantially reduce conflict and delay if they utilize these maps to select sites at which minimal conflict is likely to occur. Consultation with the relevant state and federal regulatory agencies also can help to reduce conflict and delay, particularly if such consultation is undertaken in advance of detailed project design. The preliminary permit process administered by the FERC provides a productive process for such consultation, since it allows potential problems to be identified by agencies or other reviewers early on in the feasibility stage of project development.

Additionally, it has become clear during the course of the study conducted by NERBC that opposition to the construction of new dams at previously undeveloped sites is likely to be substantial. In many cases development of hydropower at such sites would conflict with already established uses of major significance to the region. In a region where there already exist in excess of 10,000 dams, the number of remaining, free-flowing river segments is limited. Many of these sites are highly valued for their fisheries and for their recreational, scenic, and other assets. If these assets were lost as a result of the construction of new impoundments, it would not be possible to compensate for the loss. Thus, while the merits of hydropower development at new dams relative to the merits of maintaining and protecting competing uses will obviously have to be evaluated on a case by case basis, developers should recognize that proposals for construction of entirely new facilities will not be easily implemented, regardless of any changes in the regulatory process.

The reference to a comprehensive plan in Section 10A of the Federal Power Act suggests a final approach to avoiding conflict. The development of comprehensive plans, as a result of cooperation between development interests and appropriate state and federal agencies would provide a basis for coordinating the development of hydropower facilities with the protection or enhancement of other river dependent uses.

There are certain advantages inherent in a basinwide approach that are not available in the site by site development process. These include the following:

- the potential to optimize power output by augmenting stream flow with upstream storage and by coordinating flow releases to accommodate the load and operational requirements of facilities throughout the system;
- the ability to limit mainstem operations to run of river facilities, and to place only in upstream tributaries the storage facilities needed to even out flows;
- the flexibility to negotiate compromises in favor of hydropower at certain sites in return for accommodating different uses at other locations; and
- the ability to enhance a variety of objectives concerning river use, such as using upstream storage to lengthen the season for which flow is sufficient for recreation as well as for hydropower generation.

Chapter I: Introduction

Study Background

In the Water Resources Development Act of 1977 (PL 95-199) Congress authorized the New England River Basins Commission to conduct a study of hydropower expansion in the New England region. Major objectives of the study were the following:

- to assess the feasibility of hydroelectric development at existing dams and undeveloped sites throughout the New England region;
- to clarify the issues which arise from the competition between hydropower development and other uses of water resources, and to assess the potential for conflict resulting from such competition; and
- to provide information and data which will facilitate either the avoidance or resolution of competing use conflicts.

In partial completion of the first objective, a report, *Potential for Hydropower Development at Existing Dams in New England*, was released in January of 1980. Completion of the feasibility analysis of undeveloped sites and fulfillment of the remaining objectives is the goal of this second report.

Purpose of This Report

The public has certain rights to the use of water derived from common and statutory law, judicial decisions, and public policy. Some rights to the use of water are exchanged via the free market system. Others are granted or protected by controls superimposed on the market system by government. Government has not prescribed uniform public rights to the use of water for every river, however. Indeed, for many rivers in New England, the extent and significance of public rights are unknown.

A substantial number of hydropower sites will be developed in the region in the next ten to twenty years. Applications involving more than 200 sites already have been submitted to the Federal Energy Regulatory Commission (FERC) as part of the preliminary permit process. Within the next two years, many of these sites will be brought before the FERC and other state and federal agencies for a determination of whether a license to construct and operate a facility should be granted, and if so, under what conditions. In many cases, such a determination will involve an evaluation of the right to use water for hydropower generation vs. the right to use it for other public purposes.

Negotiation between project applicants, competing water users, and public agencies will play a large role in these determinations. Negotiation will be particularly critical in situations where there is a lack of articulated priorities or policies for use of a river segment; i.e. where the significance and extent of competing public rights are unknown and must be balanced in the licensing process.

With this in mind, this report is designed to do the following:

- provide an overview of the benefits which will accrue to the region from hydropower development (Chapter II);
- explain which types of conflicts arising from development will require negotiation (Chapter III);
- clarify the extent to which conflicts among competing uses are likely to arise, and identify the basins where or the conditions under which negotiations will be most intense (Chapters IV, V);
- describe the positions and perspectives of the negotiating parties, particularly with respect to the use of instream flows (Chapter VI); and
- explain the means by which conflicts can be avoided or their effects mitigated (Chapter VI).

Chapter II: The Role of Hydropower in the Region

Generating Potential at Existing Dams

In its January 1980 report, *Potential for Hydropower Development at Existing Dams in New England*, NERBC presented the findings of a computer analysis of over 10,000 sites of existing dams. That analysis indicated that as many as 1748 sites have the physical capability to produce at least 50 kilowatts of electricity. The distribution of these sites among the six New England states is presented in Table 1 below for each of two plant factors*:

Table 2-1: Sites of Existing Dams with a Potential Capacity of at Least 50 Kilowatts

	40% Plant Factor			70% Plant Factor		
STATE	No. of Sites	Potential Capacity (Mw)	Annual Energy (Mwh)	No. of Sites	Potential Capacity (Mw)	Annual Energy (Mwh)
CT	202	87	307,000	116	35	217,000
ME	465	368	1,282,000	312	154	942,000
MA	295	115	401,000	118	46	284,000
NH	535	260	916,000	353	108	659,000
RI	99	38	135,000	70	16	97,000
VT	152	134	471,000	115	59	353,000
TOTAL	1,748	1,002	3,512,000	1,154	418	2,552,000

Note: Figures do not include sites currently generating hydroelectricity at which additional capacity could be installed. (For example, the Corps of Engineers estimates that there are 130 Mw of potential additional capacity in Maine, with a potential annual energy output of 640,000 Mwh.) The sites listed under each plant factor are not necessarily the same sites.

Subsequent computer screenings, based on a common set of assumptions regarding costs of construction and financing, were used to identify the more economically favorable sites from among the 1,748 sites. Given the current high interest rates and the fact that the majority of sites now under investigation will be financed primarily by the private sector, an interest rate of 15% was assumed to represent an appropriate cost of financing. Using this rate in the computer model, it was determined that approximately 300 sites could be developed, each of which could produce energy at an estimated cost of less than \$.125/kwh.** By comparison, rates to be established by state public utility commissions for electricity produced by small scale hydro sites in New England are

* Plant factor is the ratio (expressed as a percent) of the average annual energy actually generated by the plant to the energy which could be generated if the plant operated at full capacity for the entire year. A 100 kw plant, for example, which has an average output of 70 kw over the course of a year, has a plant factor of 70%.

** See Appendix A for a listing of the sites and screening criteria. The sites are shown on the maps accompanying this report.

Typical low-head New England dam. Photo: Bob Sabbatini

Table 2-2: Sites of Existing Dams at which Hydro Development is Economically Most Attractive

STATE	40% Plant Factor			70% Plant Factor		
	No. of Sites	Potential Capacity (Mw)	Annual Energy (Mwh)	No. of Sites	Potential Capacity (Mw)	Annual Energy (Mwh)
CT	33	62	217,000	37	29	178,000
ME	67	235	818,000	78	126	773,000
MA	54	122	422,000	54	54	331,000
NH	80	132	463,000	92	64	393,000
RI	19	19	65,000	22	10	61,000
VT	35	64	147,000	37	29	178,000
TOTAL	288	612	2,132,000	320	312	1,914,000

Note: For the purposes of this screening, an interest rate of 15% and a maximum energy cost of $.125/kwh were used. Flood control dams constructed by the Corps of Engineers were not included in this analysis because of their unique operating constraints. There are 53 such dams in New England; less than 50% are estimated by the Corps to be practical sites for hydroelectric generation. Unlike the data shown in Table 2-1, virtually all of the sites which met the screening criteria at a 40% plant factor met the criteria at a 70% plant factor.

estimated to be between $.06 and $.09/kwh. Table 2-2 displays the results of this analysis.

If all of the sites listed in Table 2-2 were developed over the next few years, their aggregate annual output would be between 1.9 and 2.1 million Mwh for 70% and 40% plant factors respectively. Most of the generating potential is dispersed among sites in the 1-10 Mw range in the northern New England states. (A few large sites in the 10-20 Mw range account for much of the potential capacity identified in Massachusetts, although there are many potentially feasible small sites in that state.)

Generating Potential at New Dams

NERBC, with the cooperation of the New England Division of the U.S. Army Corps of Engineers, also has conducted an analysis of the generating potential of sites where no dams previously existed. Sites were initially identified using the 1954 New England-New York Interagency Committee Study: *The Resoures of the New England-New York Region* prepared by the U.S. Army Corps of Engineers. They were then screened using a methodology similar to that used in the analysis of the sites of existing dams*. The results of this analysis are shown in Table 2-3 below.

Table 2-3: Undeveloped Sites at which Hydro Development is Economically Most Attractive

	40% Plant Factor			70% Plant Factor	
STATE	No. of Sites	Potential Capacity (Mw)	Annual Energy (Mwh)	Potential Capacity (Mw)	Annual Energy (Mwh)
CT	2	14.3	50,300	8.2	50,300
ME	31	300.1	1,156,500	188.6	1,156,500
MA	1	7.4	25,799	4.2	25,800
NH	4	101.9	356,900	58.2	356,900
RI	—	—	—	—	—
VT	6	21.2	174,758	12.1	74,200
TOTAL	44	474.9	1,663,700	271.3	1,663,700

Note: For the purposes of this screening, an interest rate of 15% and a maximum energy cost of \$.115/kwh were assumed. This lower cost threshold was used because transmission costs were not included in the analysis. In estimating power output, it was assumed that all available flow would be utilized for power generation; therefore annual energy is the same for both plant factors. Figures for the Dickey-Lincoln project for the St. John River Basin are not included.

As indicated, development of all of these sites would provide an estimated annual energy output of approximately 1,700,000 Mwh, with about 70% of the total generating potential located in Maine.

Undertaking an inventory and analysis of over 10,000 dam sites obviously required the use of a general set of engineering, hydrologic, and economic criteria. Therefore, the information presented in Appendices A and B should be used only for comparing the relative economic favorability of sites. A more rigorous analysis which would take into account specific site characteristics or financing variables (e.g., alternative penstock configurations or investment tax credits) was not possible. A detailed feasibility study of any one site may yield substantially different results

* See Appendix B for a listing of sites and screening criteria. The site locations are also indicated on the maps accompanying this report

depending on the criteria applied. Nevertheless, the figures presented in Tables 2-2 and 2-3 are valid for purposes of describing the relative merits of sites.

The results of the screenings based on capacity and economic viability discussed above provide a) a gross estimate of the *maximum amount of* generating capacity and energy potentially available from hydropower development at existing dams and undeveloped sites; and b) a fairly realistic appraisal of the number, capacity, and annual energy output of sites which may be economically feasible to develop over the next few years. It should be noted, however, that no projections have been made of additional capacity potentially developable at sites already generating power or of capacity which might be developed using a basinwide approach wherein upstream storage would be utilized to supplement downstream generation. The state of Maine, for example, has proposed a comprehensive investigation of the St. John River Basin to examine the feasibility of multiple purpose development of upstream storage sites to provide regulated flows for a dam at Lincoln School.

Energy Security

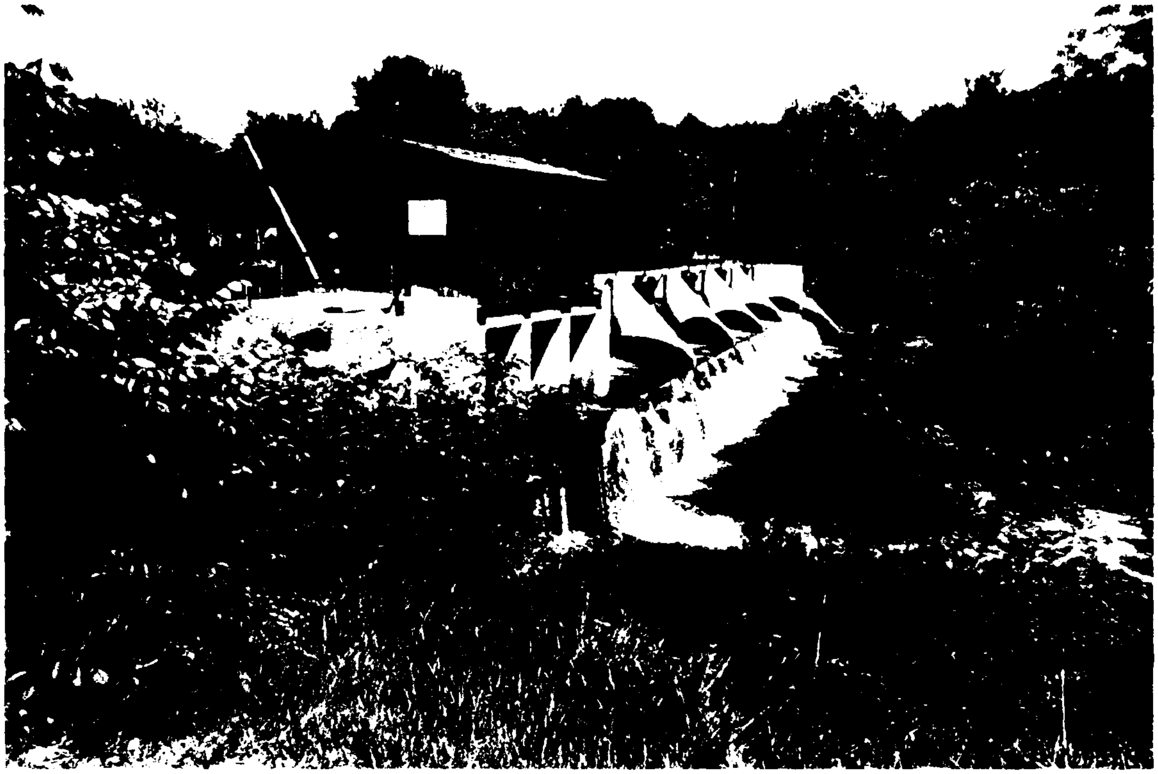
Much of the current interest in hydro development is the result of legislative initiatives designed to reduce the nation's dependency on the use of foreign oil to generate electricity. As shown in Table 2-4, New England is particularly dependent on oil-fired generation: about 60% of the electricity generated in 1980 came from oil-burning power plants (which burned about 78,000,000 barrels of oil).

Table 2-4: Comparison of Fuels Used to Generate Electricity in New England in 1980
(Figures in millions of kilowatt hours and percent)

STATE	Coal	Nuclear	Hydro	Oil	Gas	Total
CT	—	11,835	250	12,614	—	24,698
MA	1,794	3,232	96	29,297	428	34,845
ME	—	4,404	1,443	2,055	—	7,903
NH	2,734	—	872	2,365	—	5,971
RI	—	—	1	483	480	964
VT	13	2,979	743	72	12	3,820
NE	4,541	22,450	3,405	56,886	920	78,202
	(5.8%)	(28.7%)	(4.4%)	(60%)	(1.2%)	(100.0%)

Source: Electric Council of New England, preliminary figures for 1980

Hydro currently contributes between 4% and 6% of the electricity generated in the region annually; it is hoped that this amount can be substantially increased. However, from a regional perspective, the total contribution that the development of new hydropower capacity can make to reduce our dependence on imported oil is likely to be limited. If, for example, all of the approximately 300 existing dams listed in Table 2-2 that ranked most favorably on the NERBC inventory were retrofitted



Existing dam on the Salmon Falls River in New Ham[illegible] Pho[illegible] Sabbatini

with hydroelectric power plants, they would provide an oil savings of about 3.5 million barrels, or about 4.5% of the total amount of oil consumed in 1980 to generate electricity in the region.

Given uncertainties with respect to interest rates, the availability of capital, possible environmental problems, and other factors, it is impossible to predict how many facilities will actually be built and brought on-line over the next ten years and into the future. It is likely that a sufficient number of existing dams will be retrofitted to produce an oil savings on the order of 2-3%, and current oil consumption could be reduced by another 1-2% if roughly one-third of the sites for new dams listed in Table 2-3 were developed.

The principal role for any hydroelectric facility which comes on-line will be to eliminate or "back out" the need for less efficient oil-fired generation whenever possible. Under the current operating framework coordinated by the New England Power Pool (NEPOOL), all of the electrical utilities in New England cooperate in an arrangement whereby the use of generating facilities throughout the region is shared among them to meet demand whenever and wherever it [illegible]rs. The region's power plants are interconnected through a regiona[illegible] [illegible]ansmission grid and are utilized to meet demand in order of their efficiency, i.e., the most efficient plants are run around the clock to meet base load demand and the less efficient plants are brought on line to meet demand during peak periods of the day. Whenever hydropower can be integrated into this system through the purchase of power from privately or municipally owned dams or development by the utilities themselves, it will be used by utilities to preclude the need for generating oil-fired electricity or for importing it from other areas.

In combination with other alternative sources, even a small amount of new hydroelectric generation will help to offset some of our dependence on foreign oil. Conservation efforts have, for example, brought NEPOOL's projections of annual increases in energy demand for the next fifteen years down to a level of about 2.7%, considerably lower than the 5-6% annual growth rates exhibited during the pre-embargo years of the early 1970s. To the extent that hydro can make a similar contribution by providing a small-scale, decentralized alternative to oil fired generation, the region's energy situation will be improved.

Rate Impacts

Will hydro provide a less expensive alternative to imported oil? Titles II and IV of the Public Utility Regulatory Policies Act (PURPA) enacted by Congress in 1978 were designed primarily to stimulate the development of small-scale power production and bring new facilities, including hydro facilit[illegible]s on-line as quickly as possible. To achieve these goals, PURPA provides that utilities must purchase power generated by small-scale facilities, and that the rate paid for this power should be based on the principle of incremental or avoided cost*.

In essense, these provisions have provided a guaranteed market for hydropower and in New England have established the cost of oil (or a fixed percentage of it) as the basis for purchase rates to be negotiated between small-scale producers and utilities. Under the procedures established by PURPA, the Public Utilities Commission in each state is responsible for establishing a methodology upon which the avoided cost rate can be determined on a case by case basis or for setting a uniform statewide

* "Incremental or avoided cost" is the cost utilities would have to incur to produce an equivalent amount of power by alternative means or purchase it from other suppliers

rate*. As of this writing, only New Hampshire and Vermont had established statewide rates. The other state PUC's were in various stages of completing their responsibilities under PURPA through the promulgation of regulations. Based on the available information, however, 1981 PURPA rates for the various New England states are estimated to be as follows:

Table 2-5: PURPA Rates in New England

STATE	Rate (mills/kwh)	STATE	Rate (mills/kwh)
Connecticut	56 non-firm 71 firm	Rhode Island	0-85
Maine	70	Vermont	66 off peak 90 peak 78 average
Massachusetts	70-80		
New Hampshire	77 non-firm 82 firm		

Note: 10 mills equal $.010; "firm power" is essentially dependable capacity that can be utilized at any time to meet demand. With the exception of New Hampshire and Vermont, all figures are estimates pending promulgation of final regulations and calculation of avoided costs for individual utility service areas within each state.

These PURPA rates will provide a framework within which actual power purchase contracts will be negotiated between hydro developers and utilities. These contracts will probably specify that long-term purchase rates for hydroelectricity be based on fixed percentages of the utilities' avoided costs. For example, hydroelectricity will be valued in any one year at 90 percent or more of a utility's avoided costs in that year. For a utility that continues to be heavily reliant on oil-fired generation, the price paid for hydroelectricity will rise as the costs of oil rise over future years.

This pricing mechanism was designed to stimulate development of small scale energy sources as an alternative to oil-fired generation. In the short run, it will not produce lower electric bills for consumers, assuming the price paid for hydroelectricity will be based on what utilities would have had to pay to produce the same amount of power using oil-fired generation.

* The constitutionality of the implementation procedures established by PURPA has been successfully challenged by the State of Mississippi in U.S. District Court. The case is currently under appeal to the U.S. Supreme Court.

From a regional perspective, it is unlikely that development of hydro will have much effect on consumer rates even if the sale of hydroelectricity to utilities was not tied to the cost of oil. Rates paid by consumers of electricity are based on the total costs of service provided by all generating facilities used in a system (e.g., oil, nuclear, coal, hydro), with the facilities contributing the smaller amounts of power having less effect on ultimate consumer rates. As noted earlier, the amount of hydro that probably will be developed will make only a limited contribution to the total amount of electricity generated and consumed in the region. Thus, development of hydro will have limited effect on consumer rates.

Most of the sites now being investigated for hydro development in New England are being looked at by private investors responding to the incentives provided by PURPA and other federal and state legislation. Power produced at these facilities will be sold to utilities as described above, for the purpose of "backing out" oil generation and for providing investors a fair return on their investments.

In other cases, municipal or industrial developers will seek to use the hydroelectric power directly, if it can be developed at less cost than if they had to purchase an equivalent amount of power from utilities. For example, a manufacturing facility in Rhode Island estimates annual fuel savings on the order of $300,000 - $400,000 by generating its own power through rehabilitation of an existing dam adjacent to the plant. Industries such as paper manufacturing that utilize large amounts of energy will benefit substantially from such savings, as will municipalities that can use hydropower to provide electricity for schools, waste treatment plants, and other municipal facilities.

Tax and Employment Benefits

Will expanded hydropower development play an important role in creating jobs or improving local economies and fiscal situations? The employment benefits of hydropower construction, although relatively short-term, must be recognized as significant from the point of view of affected workers and communities. Peak project employment appears to average about 10 workers for each megawatt of new capacity developed. This suggests that 6,000-11,000 jobs could be generated in New England at the peak of development of the 360 or so projects listed in Tables 2-2 and 2-3.*

The potential total wages paid for construction, as shown in Table 2-6, are estimated to be $106-$200 million, depending on whether projects are generally developed at a higher capacity with correspondingly lower plant factor or lower capacity with a correspondingly higher plant factor.

* It should be noted that the total project employment figures given here are based on the peak employment figures of many projects which may or may not be constructed at the same time. They do *not* represent a simultaneous peak in hydropower construction employment regionally.

Table 2-6: Total Estimated Wages for Construction at Existing and Undeveloped Sites

	40% Plant Factor			70% Plant Factor		
STATE	Existing	Undev.	Total	Existing	Undev.	Total
CT	$ 9.6	$ 2.9	$ 12.5	$ 5.5	$ 1.5	$ 7.0
ME	38.9	66.0	104.9	22.4	33.9	56.3
MA	21.00	1.5	22.5	11.3	.8	12.1
NH	21.7	20.4	42.1	9.9	10.5	20.4
RI	2.9	—	2.9	2.2	—	2.2
VT	11.1	4.2	15.3	5.5	2.2	7.7
TOTAL	$105.2	$95.0	$200.2	$56.8	$48.9	$105.7

Construction of hydropower facilities at previously undeveloped sites will obviously create many more jobs than retrofitting of hydro installations at existing dams, because of the need to build the dam itself as well as a powerhouse.

Increased spending by workers may also have indirect multiplier effects on income, and possibly on employment in surrounding communities. The significance of indirect effects varies with the circumstances of each project, and is of concern primarily for larger projects in relatively remote areas.

Local governments in New England are heavily dependent on property taxes for operating revenues. Property taxes are levied annually on most hydropower projects as they would be on other real and personal property. Since the property tax is levied locally, local tax revenues may be significantly boosted by development of hydropower projects.

Estimated local tax revenue increases which could result from hydropower development in New England are shown in Table 2-7, and were calculated using the total number of feasible sites listed in Tables 2-2 and 2-3. Potential revenues are on the order of $19 - $27 million, reflecting a regionwide average effective tax rate of roughly 2%. As noted in the table, Massachusetts and Rhode Island have enacted legislation providing for in-lieu of tax payments or exemptions from property taxes. Connecticut is also considering such legislation.

The figures in Table 2-7 also indicate that the capital investment needed to construct the 360 sites may exceed one billion dollars. Investment of this money in the region rather than having it diverted to foreign oil sources may make a substantial beneficial contribution to the regional economy.

Construction at the Topsham-Brunswick Dam. Photo: Bob Sabbatini

Table 2-7: Possible Additional Property Tax Revenue from Hydropower Facilities

Potential Investment in Hydropower Facilities (in $ million)				Average Effective Tax Rate (percent)	Potential Tax Revenue ($ million)
40% Plant Factor					
STATE	Existing Dams	New Dams	Total		
CT	$ 87.4	$ 15.7	$ 103.1	1.8	$ 1.775
ME	266.0	363.1	629.1	1.6 (Note 3)	10.714
MA	163.2	8.1	171.3	(Note 4)	1.330
NH	201.7	112.1	313.8	3.5	10.857
RI	37.5	—	37.5	(Note 5)	.094
VT	94.6	23.3	117.9	1.8	1.940
TOTAL	$850.4	$522.3	$1,372.7		$27.060
70% Plant Factor					
STATE	Existing Dams	New Dams	Total		
CT	$ 71.1	$ 9.9	$ 81.0	1.8	$ 1.458
ME	201.2	226.3	427.5	1.6 (Note 3)	6.677
MA	118.1	5.0	112	(Note 4)	1.330
NH	160.5	69.8	230.3	3.5	8.061
RI	37.5	—	37.5	(Note 5)	.094
VT	71.1*	14.5	85.6	1.8	1.541
TOTAL	$659.5	$315.5	$975.0		$19.161

Notes:

1. Investment value (including contingencies and interest during construction), less site acquisition cost, in 1980 dollars.
2. Statewide average rate on equalized value, based on data compiled by state agencies for various years (1978-1980).
3. Property taxes collected in the unorganized territories in Maine are paid directly to the state. Rates are low since the total tax levied cannot exceed direct state support costs for the territories. Thus, the totals shown for Maine over-estimate potential tax revenues.
4. Massachusetts law (Chapter 367, 1979) authorizes municipal governments to levy a 5% gross income tax, in lieu of property tax, on new hydropower facilities during the first 20 years following project completion. The in-lieu tax shown is assumed for all new projects, based on a rate of 7.5¢ per Kwh and a potential energy generation of 448,000 Mwh (40% plant factor) and 354,705 Mwh (70% plant factor).
5. Rhode Island law (44-3-3, 1979) exempts new hydropower generation equipment from property taxation. The exemption is assumed to apply to 90% of market value; the remaining 10% (dam improvements, all at existing sites) are taxable at an average effective rate of 2.5%.

Current Demand for Hydropower Sites

Given the estimates of the number and capacity of sites for hydropower development discussed in previous sections, how much hydro is likely to be built?

The answer to that question is uncertain. However, the combined effects of investment tax credits, a guaranteed market for small-scale hydropower, and a sales price per kilowatt hour linked to the cost of oil have stimulated substantial interest in hydro development in New England.

For the period January 1978 - May 1981, the Federal Energy Regulatory Commission in Washington D.C., received approximately 250 applications for exemptions, preliminary permits, or licenses. The distribution of these applications is shown in Table 2-8 below. The total capacity potentially available from these sites exceeds 950 Mw.

Table 2-8: FERC Exemption, Permit, and License Applications January 1978 - May 1981

	No. of Permit Applications	No. of License Applications	No. of Exemption Applications	Total Capacity (Mw)
Connecticut	25	—	—	125
Maine	42	1	1	397
Massachusetts	33	—	2	90
New Hampshire	69	11	3	130
Rhode Island	16	2	1	8
Vermont	33	13	1	211
TOTAL	218	27	8	961

A comparison of the sites designated in these applications with the sites identified in the NERBC estimates of development potential indicates that many of the sites at which development appears feasible are already being investigated. Many of the existing site applications submitted to the FERC are for the same sites listed in Appendix A and shown on the maps accompanying this report. Several of the new site applications are for projects other than those listed in Appendix B, however. This results from differences in site selection criteria used by project applicants and the Corps of Engineers, who prepared the new site inventory for NERBC.

Almost 70% of the projects are being considered by private developers, with about 80% of the projects involving the retrofitting of existing dams with hydro generating equipment. Entirely new facilities are being considered for construction at 35 previously undeveloped or fully breached sites.

Most of the projects are in the 500 kw to 5 Mw range, with about 70 to 80% of them in the low head category of under 60 feet. Several larger projects, most of them involving new dam construction are also proposed.

The types of projects being investigated are characterized in Table 2-9 below.

Table 2-9: Types of Hydro Projects in New England Currently Being Investigated for Development

		Number	Percent
Developer Type:	Private	138	67
	Public	57	28
	Combination	10	5
	Unknown	27	—
Dam Type:	Existing	166	83
	New	35	17
	Unknown	30	—
Head:	Less than 25 feet	60	43
	25 feet - 50 feet	43	30
	51 feet - 100 feet	29	21
	Greater than 100 feet	9	6
	Unknown	92	—
Capacity:	Less than 500 kw	60	27
	500 kw - 5,000 kw	130	58
	Greater than 5,000 kw	34	15
	Unknown	8	—

Note: The figures in Table 2-9 include only those projects which have been entered into the FERC process. Examples of excluded projects include major public projects such as the Dickey-Lincoln St. John Basin Study being conducted by the Corps of Engineers in Maine.

Chapter III: Hydro Development and Competing Uses

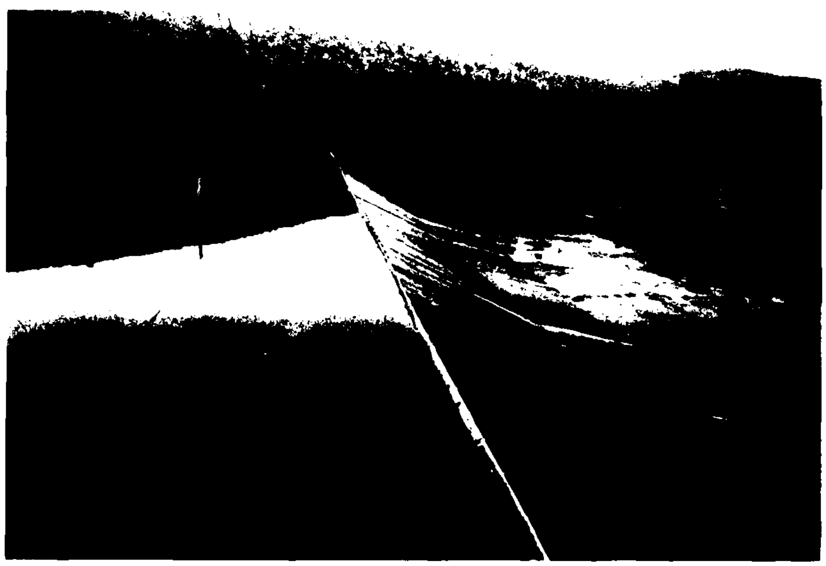
Introduction

Because the generation of hydropower is only one of many uses of New England's rivers and streams, the development of hydropower facilities may conflict or compete with other water resource activities and values. The severity of any conflict will be highly site-specific, and will depend on the type and configuration of the hydro installation, the mode of operation, the environmental characteristics of the site, and the use of surrounding lands. The interrelationships between these factors are summarized in the following sections.

Dam Types and Operating Modes

Hydro development may involve the retrofitting of an *existing dam* with hydroelectric turbines and generating equipment, the rehabilitation and retrofitting of a *breached dam**, or the construction of a *new dam* and powerhouse.

Of 253 permit, license, and exemption applications submitted to the FERC as of May 1981, roughly 83% involved the retrofitting of existing dams, 8% involved the rehabilitation of breached dams, and 9% the construction of entirely new facilities.



Existing dam on the Androscoggin River. Photo: Bob Sabbatini

* For the purposes of this report, the term "breached dam" refers to dams which have been physically damaged by floods or other causes to the extent that water flows through them more or less unobstructedly.

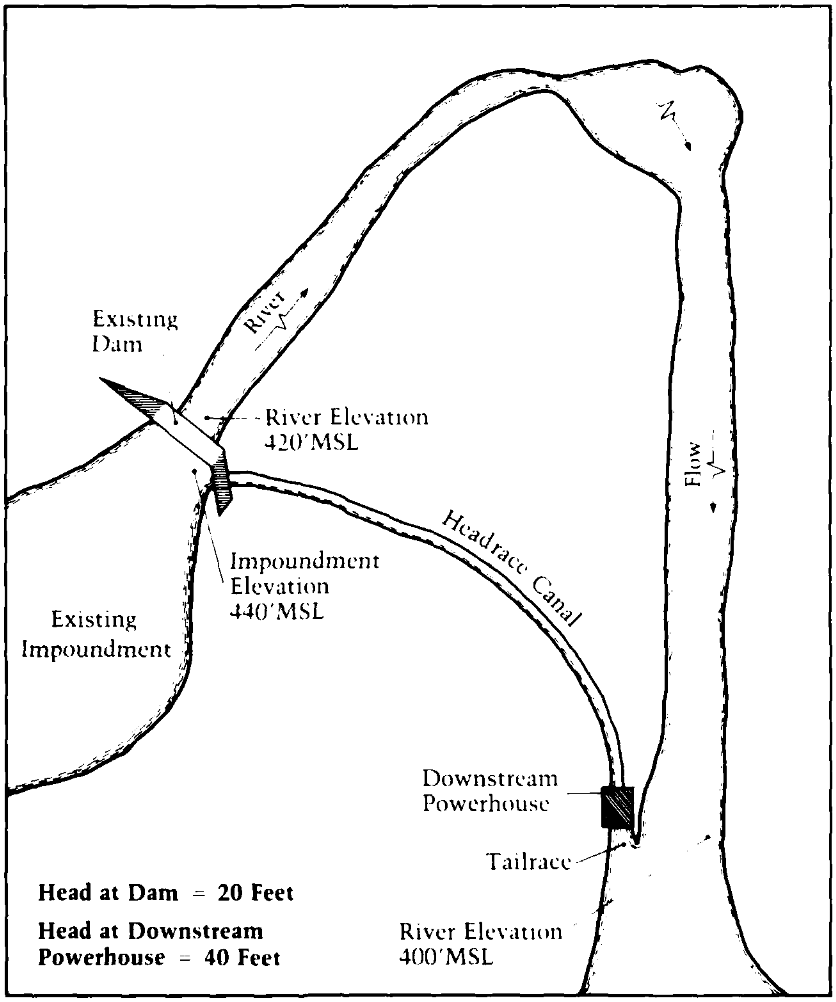


Figure 3-1: Headrace Diversion at an Existing Dam

The design of a hydro installation at either of these three types of dams may involve the utilization of an enclosed *penstock* or of an open canal called a *headrace*. Penstocks or headraces are used to divert flow out of the mainstem of a stream to a powerhouse sited downstream to gain more head for the production of power (see Figure 3-1). The inclusion of such diversions in proposed hydropower facilities in New England appears to be fairly common, and the penstocks or the headrace canals proposed can be of considerable length. (See Table 3-1).

Table 3-1: Summary of Proposed Diversions for Project Applications Submitted to FERC as of May 1981

Diversion Length	No. of Projects	% of Projects for Which Configurations are Known
No diversion	38	23
1 foot - 300 feet	42	26
300 feet - 1000 feet	36	22
Greater than 1000 feet	46	29
Length of or Needs for Diversion Unknown	70	—

There are two basic modes of operation: *run-of-river* and *store-and-release*. In a *run-of-river mode*, the amount of flow released downstream of the installation equals the amount of flow entering the impoundment upstream of the dam at all times. Run-of-river facilities can be developed on rivers whose flow either is in an uncontrolled, natural condition, or is regulated by other facilities upstream.

Store-and-release facilities utilize the storage capabilities of impoundments to provide hydroelectricity on a cyclical basis. Water is stored in the reservoir behind the dam during periods of limited electrical demand and released through the turbines during periods of peak demand. The level of the water in the impoundment fluctuates accordingly. Store-and-release cycles can be on a daily, weekly, or seasonal basis depending on the amount of storage available in the impoundment and the desired use of the electricity generated.

Most projects in New England involving existing dams will be operated in a mode approximating run-of-river because of the limited storage capability of their impoundments. (The term run-of-river is often broadly interpreted to include a limited amount of fluctuation in flow releases.) Both run-of-river facilities and store-and-release facilities can employ penstock or headrace diversions.

Conflicts between Hydropower and Competing Uses

The instances in which the various types of hydropower facilities and operating modes will conflict with competing uses are displayed in the matrix below (Table 3-1). The nature of each type of conflict is discussed in subsequent sections.

Table 3-2: Competing Uses Conflicts

	Type of Dam and Configuration				
Competing Uses	Existing Dams	Breached Dams	New Dams	Diversion Structure	Mitigation Measures
Water quality, waste assimilation	s-a-r	r-o-r s-a-r	r-o-r s-a-r	r-o-r s-a-r	Maintain adequate flow releases, venting, aeration.
Habitat, wetlands, deer yards, rare & endangered species		r-o-r s-a-r	r-o-r s-a-r	r-o-r s-a-r	Set aside other habitat elsewhere.
Anadromous fishery	r-o-r s-a-r	r-o-r s-a-r	r-o-r s-a-r	r-o-r s-a-r	None, if habitat destroyed provide fish passage, maintain adequate flow releases.
Freshwater fishery	r-o-r s-a-r	r-o-r s-a-r	r-o-r s-a-r	r-o-r s-a-r	None, if habitat destroyed maintain adequate flow releases, adjust turbine intake placement.
Land Use					
• Agriculture, forestry, mineral extraction		r-o-r s-a-r	r-o-r s-a-r		None if irreplaceable resources; compensation
• Residential, commercial industrial development & recreation		r-o-r s-a-r	r-o-r s-a-r		Relocation; compensation
• Lakeshore development & recreation	s-a-r	r-o-r s-a-r			Maintain satisfactory lake level fluctuation regime.
• Historical & archeological sites		r-o-r s-a-r	r-o-r s-a-r		Survey, restoration, relocation.
Whitewater recreation	s-a-r	r-o-r s-a-r	r-o-r s-a-r	r-o-r s-a-r	None if whitewater reach inundated; maintain scheduled flow releases; provide portage facilities.
Scenic Rivers		r-o-r s-a-r	r-o-r s-a-r	r-o-r s-a-r	None if scenic reach flooded; maintain adequate flow releases for downstream reaches.

Note: r-o-r: run-of-river mode of operation
s-a-r: store-and-release mode of operation

The operation of retrofitted, existing dams in a run-of-river mode will pose few conflicts with other uses, *providing the facilities do not involve significant diversions of stream flow*. Rehabilitation of breached dams or construction of new dams will result in the creation of new impoundments and may cause conflicts with competing uses. Store-and-release operations will conflict with competing uses that depend on pre-existing patterns of lake level fluctuation or downstream flow.

The matrix displays only individual site effects or conflicts. Systemwide or cumulative effects may also occur where a number of sites are developed over the length of a basin. For example, development of one new dam in a basin might reduce anadromous fish populations by only 10%, but a series of successive new dams in the basin might result in an overall reduction of 30% or more.

Not every impact of hydro development is necessarily negative. For example, regulation of streamflow by hydropower installations may lengthen the season during which canoeing or white water rafting is possible on certain rivers. Hydropower projects can be designed to include features which increase access to the water for recreational purposes, such as canoe portages or launching ramps. Provision of fish passage at existing barriers may enhance fish restoration efforts. Retrofitting of existing dams might entail restoration of historic structures such as powerhouses and dams. The creation of new reservoirs by the construction of new dams or the repair of breached dams may be desirable in urbanized areas or in places where there is demand for lake recreation such as motorboating or swimming.

Water Quality

One of the assets of hydropower is that, unlike some other energy sources, it does not require the discharge of pollutants into the air or water. However, hydropower installations can have unwanted effects on water quality. Creation of new or enlarged impoundments can cause stratification, or the separation of waters of different temperature into layers. Oxygen content can be reduced by the warming of shallow waters in new or enlarged impoundments, and by the increased accumulation of organic nutrients. The depletion of oxygen can also occur if a segment of rapids, which causes natural aeration, is replaced by an impoundment or by-passed by a diversion structure. Other possible effects are the accumulation of pollutants in sediments above a dam, requiring dredging and disposal, or the restriction of flow such that too little water is provided for the river to assimilate wastes discharged into it downstream.

Modifications of the design of the hydropower facility can reduce or eliminate the problem, mentioned above. For example, stratification can be prevented by proper placement of the penstock or headrace intake within the dam. Turbines equipped with venting devices or other aeration features may offset losses of natural aeration, as can maintaining spillage over the dam. Maintenance of adequate flow releases can prevent problems with waste assimilation downstream.

Wildlife Habitats

Wildlife may be endangered by hydro development at new or breached dams if creation of new impoundments causes the inundation of critical habitat.* At dams where impoundments already exist, impacts on wildlife habitats will occur only if the patterns of fluctuation of the lake levels are altered by new procedures for operating the dams. Such fluctuations create a zone around the impoundment which is subject to periodic innundation. These zones usually support only limited vegetation, in contrast to the shores of natural lakes and rivers, which support a wide variety of vegetation. Loss of plant life along these shores may destroy habitat and nesting sites important to water fowl and other wildlife.

While almost every type of land serves as a habitat for some species of plants and wildlife, highly productive habitats such as wetlands, critical areas such as deer yards, and lands which support rare, threatened, or endangered species are of special concern.

When unique habitats are destroyed by the creation of new impoundments, when they are altered by changes in lake levels or when they receive less water because stream flows are diverted, they may not be replacable. In such cases, there is no way to lessen the damage. However, in cases in which the habitat affected is not unique it may be possible to insure the preservation of an area serving as an equally valuable habitat elsewhere through acquisition or through purchase of conservation easements. It may also be possible to increase productivity elsewhere to offset wildlife losses at an impoundment site.

Federal and state fish and wildlife agencies can provide information about the location and special characteristics of rare and endangered species. Reconnaissance surveys by prospective developers can be used to assess the characteristics of a habitat which may be important to these species.

* Clearing of corridors for transmission lines may have similar effects.

Anadromous Fisheries

Anadromous fish are fish that spend their adult lives in the sea before migrating upstream into freshwater rivers and tributaries to spawn. The New England species which are anadromous include the Atlantic salmon, the alewife, the American shad, the rainbow smelt, the blueback herring, the Atlantic sturgeon and the endangered shortnose sturgeon. Landlocked salmon, though not technically considered "anadromous" species, live in large lakes and migrate upstream to spawn.

In many cases, the construction of dams has already impeded the upstream migration of these fish. Retrofitting of these dams with run-of-river hydropower facilities located at the dam generally is unlikely to further degrade the fishery resource.

In some cases, however, upstream reaches or tributaries are used by fishery agencies for stocking and for the release of juveniles. These fish are able to migrate downstream in the spillage over the tops of dams. Reduction or elimination of such spillage and diversion of flow through newly installed turbines could substantially reduce the number of fish which can migrate downstream to return to the river system in other years. Repeat spawners are extremely important for the maintenance of population levels of some species such as the American shad.

Development of sites at which rivers are currently free-flowing can cause the greatest impact on anadromous fish and the fishery. Nursery and spawning habitats upstream of the dam site can be lost when an impoundment is created, and construction of the dams will obstruct both up and downstream migration of fish. Fishing sites may also be eliminated. Although fish migrating upstream can pass a number of successive dams equipped with fishways, their numbers are depleted at each one by as much as 10% - 20%, thereby resulting in a severe cumulative reduction in overall population.

If the development of a site includes a diversion, much of the flow in the river will be directed through the penstock or canal. The stretch of river that is bypassed will receive substantially less water. The reduced flow may exacerbate upstream and downstream migration problems, particularly if the flow out of the tailrace attracts fish and confuses them while they are migrating upstream. Low water levels in the river between the dam and the tailrace may not provide enough water for spawning and nursery habitats, and it may reduce the level of oxygen in the water and raise the water temperature.

Operation of a hydropower facility in modes other than run-of-river causes fluctuations in the water levels above the dam and in flows downstream. Fluctuating water levels in impoundments can affect spawning and nursery habitats. Downstream effects can include the dewatering of the river during storage periods, causing increased water temperature, reduced levels of dissolved oxygen, or elimination of spawning and nursery habitat.

With the exception of the flooding of the habitats of anadromous fish by the creation or enlargement of impoundments, most of the adverse effects of hydro development can be eased by providing facilities for fish passage and by adhering to flow releases scheduled to accomodate the needs of fisheries during different seasons of the year. The retrofitting of existing dams may in fact help to restore some habitats if it includes the installation of fish passage facilities where none previously existed. (On the other hand, such retrofitting may conflict with plans agencies may have had for eventual removal of the dams.) Facilities for fish passage can include trap and truck programs, stepped fishways or ladders, or elevator systems. Maintenance of minimum flow releases can ensure that adequate flow is provided in segments critical for migration, spawning, or other habitat.

Fresh Water Fisheries

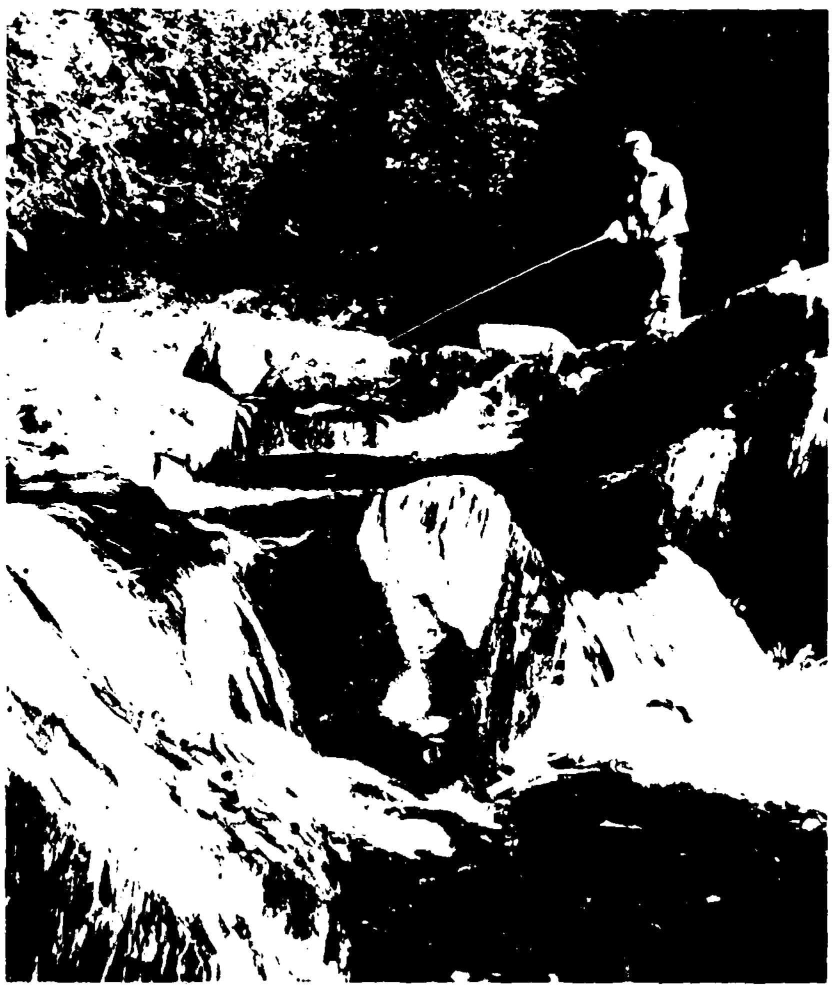
Fresh water fisheries support resident cold and warm water species. Unlike anadromous fish, resident fish spend their lives in one general area. However, they may undergo seasonal movements to feed, spawn or seek other suitable habitats. Cold water species such as trout require cold, well oxygenated, high quality water. Warm water species such as the largemouth bass can tolerate warmer conditions and less oxygen content.

Fresh water fisheries will generally not be affected by the retrofitting of existing dams with run-of-river power facilities installed at the base of the dam. Rehabilitation of breached dams or construction of new dams, however, may inundate upstream spawning and nursery areas. In addition, a free-flowing stream supporting a cold water fishery may be converted to an impoundment which could only sustain warm water species. A repaired dam can be a barrier to fish movement, blocking off access to upstream spawning habitats or cool springs that serve as refuges from high summer water temperatures. New impoundments may result in increased water temperatures with adverse effects on downstream habitat.

If development of an existing, breached or new site includes a diversion, the impacts of the project are increased because much of the flow in the river will be directed through the penstock or canal. The stretch of river that is bypassed will receive substantially less water. Reduced flow levels between the dam and the tailrace may dewater spawning, nursery and adult habitat, reduce oxygenation if rifles are lost, and may raise water temperature.

Fluctuating levels of impoundments associated with store and release operations can adversely affect riparian spawning and nursery habitats along the shore of impoundments. Downstream effects can include the dewatering of the river during storage periods, the raising of the temperature of the water, and the lowering of the levels of dissolved oxygen.

As in the case of anadromous fish, impacts caused by the flooding of upstream habits of fish cannot be mitigated. The proper placement of turbines and intake facilities, however, can minimize temperature changes that might otherwise adversely affect a cold or warm water fishery located in an impoundment or stream. Maintenance of appropriate flow releases at the dam and powerhouse can be used to prevent adverse dewatering effects downstream. Continuous flow releases generally will be required for this purpose, though the quantity of flow needed may vary from season to season.



Trout fishing on a Vermont stream. Photo: Vermont Development Department

Land Use

New hydro installations at existing dams are unlikely to affect land use significantly if they are operated either in a strictly run-of-river mode or in a manner consistent with pre-existing patterns of flow regulation. However, considerable concern has been voiced in New England that the recreational use of lakes and associated second home development will be negatively affected if patterns of lake level fluctuation are substantially altered through operation of new hydro facilities at formerly abandoned dams.

In many vacation areas of New England, artificially created lakes and impoundments have become the loci of substantial developments of second homes, and of tourism and recreational activities. These uses depend on either stable lake levels or changes in levels that are predictable on a seasonal or annual basis. A change in the way water levels fluctuate could jeopardize access to the lake and/or its suitability for swimming, boating, and other recreation activities, and could result in a decline in shoreline property values and in the income from tourism which depends on the use of the lake.

There is also concern that the construction of new dams or the reconstruction of breached dams will create new or expanded impoundments which may inundate developed areas, public infrastructure, scarce agricultural lands, historic sites, or archaeological features. Highways, agricultural uses, and archeological sites in particular are generally located in rural valleys alongside riverbeds where gradients are gradual, and the soil is fertile. Native settlements often were located in these areas to take advantage of the opportunities for fishing, transportation, and other possible uses of the river. The remains of these settlements are vulnerable to inundation.

Adverse impacts on recreation and on lands along lakeshores can be prevented through the negotiation of schedules of fluctuation of lake levels between dam operators and property owners, or by the compensation of adversely affected parties. Relocation of infrastructure such as roads, sewer lines, or other existing improvements may be possible, depending on the size of the impoundment to be created and the surrounding constraints on land use. Surveys, relocation, or rehabilitation of archeological and historic sites may also be possible depending on the extent and condition of the finds. Scarce agricultural or timberlands may be irreplaceable, although landowners can be compensated for the commercial value of the products of such lands.

Kayaking on a New Hampshire river. Photo: David Eden

Scenic and Recreational Rivers

The negative impacts of hydro development on scenic and recreational rivers are directly related to the extent that a facility alters the upstream and downstream stretches of these segments. The retrofitting of existing dams, in cases in which the turbine is located at the dam and the project is operated in a run-of-river mode, will have little or no affect on the scenic qualities or recreational uses of a river. Recreational uses and aesthetic values can even be enhanced at these sites if canoe portages and access to the river are provided.

Upstream, free-flowing waters could be eliminated, however, by the creation of new or enlarged impoundments as a result of the reconstruction or repair of breached dams. Any rapids located directly upstream would be flooded, and where a breached dam is now passable by canoes and kayaks, the restoration of the dam would make it necessary to portage the site.

The construction of new dams on scenic and recreational segments of rivers would be in direct conflict with their present value, which largely is derived from the absence of human interference or development. Construction of a new dam and impoundment may require inundation of white water rapids, scenic gorges, or other features which constitute the scenic quality and recreational value of a free-flowing river.

Significant impacts will always occur when the natural stream flow is altered above or below any existing, breached, or new dam site. A diversion of the river through a canal or penstock for more than a few hundred feet will have a negative impact on uses which require instream flow below the dam. Store-and-release operations which produce power at times of peak demand will affect both the impoundment levels and downstream flow.

If reaches of a scenic or recreational river are flooded by the creation of a new or enlarged impoundment, no ameliorating measures are possible. Downstream impacts can be mitigated through the scheduling of flow releases to provide adequate depth and velocity for recreational uses, and the scheduling of them to coincide with periods of greatest demand. Portages and other access facilities can be used to mitigate the degree to which dams hinder passage. Such facilities can also lessen the effects of diversion of stream flow, provided the distance over which canoes or kayaks must be transported is not excessive.

Chapter IV: Analysis of the Potential for Conflict between Hydropower and Selected Competing Uses

Introduction

The previous chapter reviewed the various ways in which hydropower development may conflict with other uses of rivers. Two competing use issues have been the subject of a more in-depth, regional analysis: conflicts with anadromous and fresh water fisheries, and conflicts with protection of recreational and scenic river segments. These issues were selected for detailed analysis for the following reasons:

- Conflicts with fisheries or recreational uses may occur at almost any type of hydro installation, if the facility is located on a river reach significant for its use as a fishery or recreational resource.
- Fishery, recreation, and scenic river resources are widely recognized as regionally significant resources. They are utilized by people from a geographic area much broader than the immediate area in which they are located.
- Large sums of public and private money have been invested in the clean up of polluted rivers and in the restoration and management of fisheries.
- Considerable controversy has developed in New England during the last year with respect to minimum flow requirements for the protection of fishery resources at a few specific sites, and the extent to which similar conflicts may occur throughout the region is unknown.
- Collection and mapping of data pertinent to these issues would help facilitate the avoidance of conflict by project developers, and would help both regulators and developers to identify the need for conflict mitigation measures in advance of project design and the preparation and review of license applications.

Other issues, such as the negative impacts of lake level fluctuation on shoreline uses are more localized in nature. Although they are of major importance to decisions that will be made on specific sites, it was not possible to analyze either the potential for their occurence or their significance within the scope of this regional study.

In the following sections, programs relevant to each of the two selected competing use issues are discussed to provide some background on prior and current efforts to manage the resources involved. The location of resources relevant to the issues have been mapped at a scale of 1:500,000 on the set of maps accom- panying this report. The approach by which these resources were identified and a brief discussion of their significance is also presented to provide some perspective for considering their value relative to proposals for the development of hydropower. The potential for conflict with hydropower development is also discussed.

Anadromous Fisheries

Background

Atlantic salmon and American shad once figured prominently as sport and commercial species in New England. The damming of the region's rivers over the years has restricted runs of shad severely and has all but eliminated runs of salmon. Both the federal government and the New England states are now engaged in major efforts to restore these species to their earlier prominence. These efforts have received substantial support from sport fishing interests. Programs sponsored by the U.S. Fish and Wildlife Service and the six New England states are aimed at the provision of facilities for the passage of migrating fish around existing dams and the raising and releasing of young fish in the upper reaches of certain rivers to which they are expected to return to spawn and produce future generations.

Unloading shad from [illegible] McCrea

The passage of the Anadromous Fish Conservation Act of 1965 (PL 89-304) provided federal funds for conserving, developing and enhancing anadromous fisheries. These funds are distributed through the U.S. Fish and Wildlife Service and the National Marine Fisheries Service. This money has been used to support research, management, and restoration programs for commercial and recreational species such as Atlantic salmon, alewives, rainbow smelt, blueback herring, shortnose and Atlantic sturgeon, and striped bass.

Restoration of Atlantic salmon in New England has focused on two major interstate river basins, the Connecticut and Merrimack, and on the Penobscot River in Maine. In addition, several Maine coastal rivers, most of which are east of the Penobscot River, have continued to support runs of salmon over the years.

A cooperative state-federal program for the management of fisheries exists on the Connecticut and Merrimack Rivers. Strategic Plans for the restoration of the Atlantic salmon have been prepared for both rivers. These plans outline the restoration goals adopted by the cooperating agencies. Each of the Strategic Plans is designed to be followed by a more detailed Operational Plan which sets timetables and identifies the processes and the resources necessary to implement the Strategic Plan. The Merrimack Basin Operational Plan has been completed; the Connecticut River Basin Operational Plan is in draft form.

As a part of this process, the Policy and Technical Committees for Anadromous Fishery Management of the Merrimack basin released in early 1981 a *Fish Passage Action Plan* addressing questions regarding the upstream passage of fish for the 25-year period from 1981-2005. The plan presents a schedule for construction of facilities for upstream passage at existing dams. The schedule is subject to revision based on the rate of program development during the 25-year period. It calls for construction of facilities at seven existing mainstem dams and twelve dams located on five different tributaries. Passage requirements will receive further consideration at two additional mainstem dams. The plan defers consideration of fish passage facilities at more than 61 existing dams on tributaries until the year 2005.

The Fish Passage Action Plan does not address passage requirements for resident, non-anadromous species, nor does it address flow requirements that might be needed to sustain anadromous fish or other aquatic resources. It deals only with the problem of providing passage upstream for anadromous fish. A similar plan for the Connecticut River is currently under development.

The Strategic and Operational plans address Atlantic salmon only, while the fish passage plans do not mention species. However, in the Merrimack and Connecticut Rivers, the salmon and shad restoration programs are integrally connected because areas opened for salmon also become accessible for shad migration.

The Atlantic Sea Run Salmon Commission is the state agency principally responsible for salmon restoration in Maine. A management plan for the Penobscot River is under development, as are plans for other coastal rivers which currently support salmon runs.

In Rhode Island, shad restoration efforts have focused on the Pawcatuck River. Salmon smolt also are now being released in that basin. Restoration efforts have included dam removal and installation of two fish ladders which now allow adults to migrate 32 miles inland.

Planning for the management of other species in the rivers of New England is not as advanced; rivers which offer the greatest potential for succesful restoration have not been identified.

In addition to publicly funded programs to restore anadromous fisheries, substantial amounts of private funds have been invested in the restoration of these species. Most of this investment has involved construction of fish passage facilities. On the Connecticut River, for example, utilities operating hydropower dams have constructed or will be constructing fishways at the stations listed in Table 4-1 at a total cost of over 40 million dollars:

Table 4-1: Connecticut River Fish Passage Facilities at Hydropower Dams

Station	Utility	Passage Facilities	Capital Cost	Completion Date
Holyoke[1]	Northeast Utilities	2 elevators	$ 1.9 million	1975
Turner's Falls[2]	Northeast Utilities	3 fish ladders	$12.0 million	1980
Vernon	New England Electric System	1 fish ladder	$10.5 million	1981
Bellow's Falls[3]	New England Electric System	1 fish ladder	$6-10 million	start construction 1982 completion 1984
Wilder[3]	New England Electric System	1 fish ladder	$6-10 million	start construction 1984 completion 1986

Source: Northeast Utilities and New England Electric System

[1] The facility as it currently exists became operational in 1975. Fish passage has been a concern since the station began operation in 1950. Fish first passed the station in 1955. $1.4 million of the total cost was spent in the mid 1970's on the current facility.

[2] While fish passage facilities were constructed, the station was shut down for several months. An additional cost of $2 million for lost energy is estimated to have been incurred by Northeast Utilities.

[3] The project at Bellows Falls will not be put out to bid until January, 1982. Therefore capital costs are early estimates. Design of the facility at Wilder is not yet complete.

In providing fish passage, the utilities also forgo some power generation by providing flow down the fishways which otherwise might be passed through the turbines. Passage around the stations will allow migrating adults to reach upstream tributaries suitable for spawning.

Location of Anadromous Fisheries

With the cooperation of the relevant federal and state agencies, NERBC has mapped anadromous fisheries throughout the region at a scale of 1:500,000 (see maps accompanying this report). Four categories of runs for anadromous fish are indicated on the maps irrespective of the species which would use the runs:

- *Existing runs:* These are segments currently accessible to returning adult fish. These runs are sustained through natural reproduction, a combination of natural reproduction and hatchery production, or through the transport of adult fish from other watersheds. Some of the runs augmented with either hatchery produced fish or transported adults are expected to become self-supporting in the near future; other runs will continue to require supplementation with hatchery stocks or brood fish from other rivers.
- *Runs currently under active restoration:* These are segments where stocking or provision of fish passage facilities are now underway, but where adult returns have not yet been achieved. Depending on the species, it may take several years before stocked juvenile fish return from the sea as adults.
- *Runs proposed for future restoration:* These are segments (in Connecticut only) which are targeted for restoration at some point in the future when agency resources can be made available for projects other than those currently underway. When these projects will begin is uncertain.
- *Potential runs with inaccessible habitat:* These are segments where access to upstream habitat is currently blocked and which are a lesser priority for restoration.

There is a high probability that fish passage facilities will be required in the near future at hydropower sites located on existing runs or runs currently under active restoration. Hydropower installations proposed on segments which fall into either of the other two categories may be required to have passage facilities at some future point in time. Hydropower installations not located on any of these segments are unlikely to need fish passage facilities.

Some of the reaches within segments designated as "Potential runs with inaccessible habitat" may be utilized for anadromous fish restoration without the requirement for fish passage facilities. This would occur if an area were used to raise smolts from hatchery produced fry without the expectation that access would be available to returning adults.

Significance of Anadromous Fisheries to the Region

Atlantic Salmon. The Penobscot River in Maine, from which Atlantic salmon were almost totally eliminated, is the most important river for the species and supported a run of more than 3200 fish in 1980. A recreational catch of 837 fish was reported. Other Maine rivers supporting recreational fisheries include the Union, Narraguagus, Dennys, Machias, East Machias, Pleasant, Ducktrap, Kennebec, Presumpscot, and Sheepscot. These rivers supported Atlantic salmon runs totalling several thousand fish and known recreational catches of 515 fish.

Following the Penobscot in importance for Atlantic salmon are the Connecticut and Merrimack Rivers. Restoration efforts in the Connecticut River yielded 175 returning fish in 1980. Due to a lack of fish trapping facilities it is not known how many adult salmon returned to the Merrimack River. The goals of the restoration efforts on the Connecticut and Merrimack Rivers are to insure annual returns of 6,000 and 3,000 fish in the respective rivers, and to insure sport fishing catches of 2,000 salmon in the Connecticut River and 1,000 fish in the Merrimack River.

Although the numbers presented above may at first glance appear to be low, they represent a substantial achievement. Since the endemic strains of Atlantic salmon had been eliminated or drastically reduced, it was necessary to create new strains of the species suitable for each of the rivers.

American Shad. The American shad is an important anadromous fish for both commercial and sport purposes. The Connecticut River is the most important river for this species and is estimated by the Connecticut Department of Environmental Protection to support a population of about 522,000 fish. A commercial catch of 72,591 shad was reported in 1980.

The sport catch at the Enfield Dam, the most important recreational fishing site, was approximately 2,000 fish. Important sport fishing areas for shad are developing in other New England Rivers such as below the Lawrence Dam on the Merrimack, and on the Pawcatuck in Rhode Island. Such fishing areas are frequently found in association with dams which, by restricting passage, concentrate the fish. A limited shad fishery exists on the Narraguagus River in Maine.

Alewife. Alewives are an important commercial species and are harvested primarily for use as lobster bait (each pound of lobster caught in Maine requires roughly three pounds of alewife). The Maine Department of Marine Resources has estimated that the alewife resource could yield 20 to 30 million pounds of bait annually if managed intensively.

Sturgeon. The American sturgeon is a large bony fish which can reach 12 feet in length and can weigh approximately 190 pounds, although it more commonly reaches a size of only 7-1/2 feet in length. There is some limited commercial interest in this species in New England. A second

Table 4-2: Commercial Landings of Anadromous Fish — 1976

	Maine		New Hampshire		Massachusetts	
	Thousand pounds	Thousand dollars	Thousand pounds	Thousand dollars	Thousand pounds	Thousand dollars
Alewives	3,395	112	—	—	45	2
Shad	15	1	2	0.5	—	—
Smelt	80	28	25	9.0	—	—
White Perch	—	—	—	—	26	13
TOTAL VALUE		141		9.5		15

	Rhode Island		Connecticut		TOTAL	
	Thousand pounds	Thousand dollars	Thousand pounds	Thousand dollars	Thousand pounds	Thousand dollars
Alewives	34	2	67	3	3,541	119
Shad	3	1	392	164	412	166
Smelt	—	—	—	—	105	37
White Perch	9	3	24	9	59	25
TOTAL VALUE		5		176		347

NOAA, NMFS, *Fishery Statistics of the United States 1976*, October 1980

species of sturgeon, the shortnose sturgeon is known to occur in a number of New England rivers, including the lower Kennebec, Connecticut and Piscataqua rivers. Smaller than the American sturgeon, the shortnose sturgeon is on the Federal Endangered Species List. Efforts are being made by the National Marine Fisheries Service to document its occurrence and population levels. Hydropower developments, particularly those located on the lower mainstems of New England rivers are more likely to affect the habitats of the shortnose sturgeon than those of any of the other endangered species in New England.

White Perch. A small fish, approximately two pounds in weight, the white perch is related to the striped bass. It is more common in southern New England, where it occurs in sufficient numbers to support a commercial and recreational fishery.

The economic value of commercial and recreational fishing is difficult to assess. For some commercial species, numbers or pounds of fish landed and their off-vessel market value are published by state and county. Table 4-2 shows reported commercial landings and values for four anadromous species in 1976, the latest year for which figures are uniformly available for all states.

In the years 1939 - 1980, totals of 97,861,406 pounds of alewives, 7,805,237 pounds of smelt, and 3,450,867 pounds of shad were landed in the state of Maine, alone.

Table 4-3: Potential Conflicts Between Hydropower Facilities and Anadromous Fisheries

		Existing Dams			Breached Dams			New Sites			TOTAL		
		# of Sites	Capacity* (Mw)	Annual Energy (Mwh)	# of Sites	Capacity* (Mw)	Annual Energy (Mwh)	# of Sites	Capacity* (Mw)	Annual Energy (Mwh)	# of Sites	Capacity* (Mw)	Annual Energy (Mwh)
CT	Existing Runs	8	10.0	59,137	1	1.5	9,106	0			9	11.5	68,243
	Runs Under Restoration	3	2.2	13,656	0			0			3	2.2	13,656
	Proposed Runs	2	1.2	7,628	0			0			2	1.2	7,628
	Potential Runs	17	8.0	48,749	0			0			17	8.0	48,749
	Unaffected	6	6.4	39,049	0			2	8.2	50,405	8	14.6	89,454
ME	Existing Runs	23	34.0	208,862	5	6.0	41,618	9	52.6	322,304	37	92.6	572,784
	Runs Under Restoration	4	6.5	40,017	1	0.4	2,588	1	6.2	37,724	6	13.1	80,329
	Potential Runs	12	26.0	159,567	11	29.2	178,778	6	28.8	176,614	29	84.0	514,959
	Unaffected	21	23.2	141,956	1	0.4	2,152	15	101.1	619,718	37	124.7	763,826
MA	Existing Runs	4	1.9	11,485	0			0			4	1.9	11,485
	Runs Under Restoration	6	34.7	206,845	1	1.5	9,161	0			7	36.2	216,006
	Potential Runs	4	3.2	19,812	2	1.4	8,787	1	4.2	25,687	7	8.8	54,286
	Unaffected	35	10.6	65,251	2	1.3	7,677	0			37	11.9	72,928
NH	Existing Runs	3	2.1	12,706	1	0.7	4,378	0			4	2.8	17,084
	Runs Under Restoration	13	12.5	76,350	4	3.0	18,690	4	58.2	356,754	21	73.7	451,794
	Potential Runs	22	12.8	78,471	1	0.3	1,631	0			23	13.1	80,102
	Unaffected	45	29.8	182,660	3	3.4	20,984	0			48	33.2	203,644
RI	Existing Runs	2	0.4	2,422	0			0			2	0.4	2,422
	Runs Under Restoration	3	0.4	2,379	0			0			2	0.4	2,379
	Potential Runs	12	8.4	51,411	0			0			12	8.4	51,411
	Unaffected	5	1.0	5,979	0			0			5	1.0	5,979
VT	Existing Runs	1	1.6	9,805	0			2	4.0	24,258	3	5.6	34,063
	Runs Under Restoration	2	2.5	15,526	0			2	5.3	32,635	4	7.8	48,161
	Potential Runs	13	7.1	43,323	1	2.0	12,123	1	1.7	10,240	15	10.8	65,686
	Unaffected	16	14.9	91,275	4	1.3	7,775	1	1.1	7,033	21	17.3	106,083
TOTAL													
	Existing runs	41	50.0	304,417	7	8.2	55,102	11	56.6	346,562	59	114.8	706,081
	Runs Under Restoration	31	58.8	354,773	6	4.9	30,439	7	69.7	427,113	44	133.4	812,325
	Proposed Runs	2	1.2	7,628	0			0			2	1.2	7,628
	Potential Runs	80	65.5	401,333	15	32.9	201,319	8	34.7	160,499	103	133.1	815,193
	Unaffected	128	85.9	526,170	10	6.4	38,588	18	110.4	677,156	156	202.7	1,241,914

*Note: Capacity was estimated on the basis of a 70% plant factor. If the sites were developed at a 40% plant factor, two to two and one half times as much capacity would be installed.

The value of sport fishing is not easily quantified, although several procedures for analysis can be employed. The most common method is to assess the total amount of money which the fisherman pays in order to fish. Estimates made by using such a procedure have put the value of sport fishing for shad in the Connecticut River at $14 million. These estimates do not account for the non-monetary value of fishing nor for multiplier effects as the money spent moves through the economy.

Potential for Conflict

The greatest potential for conflict between hydropower and anadromous fisheries exists on those river segments which have existing runs and runs under restoration. On these runs, conflicts arise over stream flow and free passage, both of which are needed by the fish but can be restricted by hydropower facilities. The potential for conflict is generally more severe at breached dams and undeveloped sites.

Some potential for conflict may exist at sites on river segments which could serve as habitats for anadromous fish, but which are currently inaccessible. If fishery agencies seek to reestablish runs on these segments of rivers, questions regarding freedom of passage and amount of flow will arise. However, some of these inaccessible areas may be utilized for the production of smolt (*young salmon ready to migrate to the sea*) from releases of hatchery raised fry (juvenile salmon). These smolt will migrate downstream to mature at sea. As returning adults, they will augment the sport fishing harvest or provide eggs for hatchery operations, and they will not be expected to return to the streams into which they were released. In such cases, upstream passage would not be required and the conflict would be reduced to a question of minimum flows necessary to maintain the habitats of the smolt and to facilitate passage of the smolt downstream.

The following analysis of the potential for conflict considers only those dams located on river segments which have been identified as having some level of importance for anadromous fisheries. Dams and dam sites located upstream of these segments have the potential for causing conflict, depending upon the degree to which their alteration of flow affects important segments downstream.

In New England, 103 of 364 existing, breached, and new dam sites listed in Tables 2-2 and 2-3 are located on existing runs or runs under restoration (see Table 4-3). These hydro sites account for 248 Mw of potentially developable capacity. Hydropower facilities located at these sites would generate 42% of the energy potentially available from hydropower in the region.

Sites for 156 hydropower facilities with a combined capacity of 203 Mw and an annual energy of 1,241,914 Mwh are located on river segments that have not been identified as being of interest for the restoration of anadromous fish. The energy which could be generated at these sites represents 35% of the energy potentially available from hydropower.

A total of 259 sites with a combined capacity of 327 Mw and an annual energy of 2,057,107 Mwh appear to pose either no conflict or no immediate conflict with anadromous fish restoration. These sites account for almost 60% of the total energy potentially available from hydropower development.

Fresh Water Fisheries

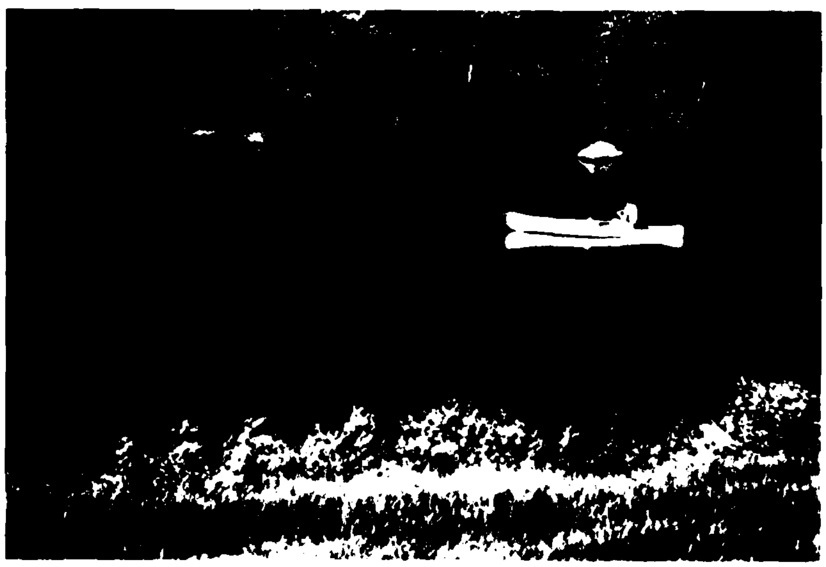
Background

Fresh water fisheries are managed primarily by state fish and wildlife agencies under the authority of state laws, with some support from the U.S. Fish and Wildlife Service. Management objectives vary by species.

Throughout most of New England, the supply of warm water fisheries exceeds the demand for them by fresh water anglers. Since, in contrast, there is a substantial shortage of cold water fisheries, fishery management focuses on cold water species.

The primary management activity is the stocking of fish, especially trout, without which many of New England's rivers could not sustain current fishing pressure. Most stocking programs occur on those rivers which have remained free-flowing, because most dammed segments have been rendered unsuitable as the result of changes in temperature or flow regimes.

While stocking is vitally important to the cold water fisheries in the region, some streams do support significant natural populations with only supplemental stocking. These streams with self-supporting populations are very important because highly prized "trophy fish" are possible only where fish can survive for several years.



Leisurely fishing in Vermont. Photo: Bob Sabbatini

Perhaps the most unique cold water fishery resources in New England are those trout streams that although they are not stocked at all contain significant populations of large, wild fish and are legendary to most fishermen. An example is the famed Battenkill in Vermont.

Location of Significant Cold water Fisheries

In recognition of the shortage of cold water sport fisheries , the potential for adverse effects on cold water species caused by hydropower development, and the relatively slack demand for warm water fishing areas, NERBC elected to map only significant cold water fisheries on the 1:500,000 scale maps (see the maps accompanying this document).

The river segments depicted as *important cold water fisheries* on these maps were identified through the cooperation of the state chapters of Trout Unlimited, Inc., the largest sport fishing group in New England. The cold water fisheries indicated on the maps are considered to be of higher than average value, and include stocked areas as well as those in which fishery populations are sustained through natural reproduction. It should be emphasized that these segments are only those considered to be most significant by knowledgeable experts, and that trout fisheries in many other river reaches not shown on the maps may be considered important by state agencies and sportsmen alike. Thus, conflicts between hydropower facilities and cold water fisheries could arise on segments not indicated on the maps.

Significance of Fresh Water Fisheries

Fresh water fishing is an extremely popular activity in New England and is very important to the tourist sector of the economy. The total number of licenses sold to fishermen in 1980 exceeded 1,000,000 and revenues from license fees paid to the states amounted to more than $7.6 million. Table 4-4 lists specific figures for each state.

Interest and investment in fishing is perennial. Studies of resident license holders in Maine reveal an average of 28 years of fishing experience. This indicates that there is a significant and long term commitment on the part of most fishermen to this form of recreational activity and that substantial amounts of money are spent annually in pursuit of it.

In several New England states, studies have been conducted to determine the fishing preferences of license holders and the amount of money license holders spent on fishing. *Hunting and Fishing in New Hampshire, 1978* indicated that nearly 80% of resident holders of fishing licenses fish for trout in streams. Table 4-5 shows resident and nonresident fishing activity in New Hampshire. The results of a similar study in Vermont are indicated in Table 4-6. While such information is not available for the remaining New England states, it is assumed that the level of participation is comparable.

Table 4-4: Sales of Fishing Licenses, 1980[1]

	ME	NH	VT	MA	CT	RI	TOTAL
Resident							
Combination[2]	83,469	42,852	52,292	53,833	62,127	7,884	302,457
Revenue[3]	$ 667,752	306,606	185,927	433,349	108,723	37,449	1,739,806
Fishing	90,578	52,487	52,837	110,096	135,039	24,139	465,176
Revenue	$ 815,202	459,261	211,348	1,131,123	675,195	156,903	3,449,032
TOTAL	174,047	95,339	105,129	163,929	197,166	32,023	767,633
Revenue	$1,482,954	765,867	397,275	1,564,472	783,918	194,352	5,188,838
Non-Resident							
Season	9,519	14,117	18,358	3,734	2,092	1,386	49,206
Revenue	$ 285,570	289,399	224,886	60,479	35,564	14,553	910,451
3-day fishing	33,273	16,801	24,353		682	704	75,813
Revenue	$ 299,457	121,807	115,677		5,456	2,464	544,861
7-day fishing	18,669	7,279		1,914			27,862
Revenue	$ 317,373	76,430		16,559			410,362
15-day fishing	8,080	2,102	7,895				18,077
Revenue	$ 161,600	32,581	69,081				263,262
TOTAL	69,541	40,299	50,606	5,648	2,774	2,090	170,958
Revenue	$1,064,000	520,217	409,644	77,038	41,020	17,017	2,128,936
Miscellaneous							
Other	11,199	672	5,501	16,787	3,643		37,802
Revenue	$ 88,817	5,012	74,197	117,640	7,286		292,952
Free Licenses	9,175	2,077		20,135	5,861	671	37,919
TOTAL	20,374	2,749	5,501	36,922	9,504	671	75,721
Revenue	$ 88,817	5,012	74,197	117,640	7,286		292,952
GRAND TOTAL	263,962	138,387	161,236	206,499	209,444	34,784	1,014,312
Revenue	$2,635,771	1,291,096	881,116	1,759,150	832,224	221,369	7,610,726

1 Some states operate on a fiscal year and some on a calendar year.
2 Both Hunting and Fishing.
3 Revenue is for fishing portion only and is apportioned using the ratio between price of fishing and hunting licenses.

Table 4-5: New Hampshire Fishing Activity, 1978

ACTIVITY	Resident Fishing		Resident Combination		Non-Resident		TOTAL
	% Reporting Participation	Projected # of Participants	% Reporting Participation	Projected # of Participants	% Reporting Participation	Projected # of Participants	Projected # of Participants
Trout fishing (streams)	79.23	34,281	85.91	34,852	66.44	25,674	94,807
Trout fishing (lakes)	37.18	16,087	—	—	30.80	11,902	27,989
Salmon fishing (land-locked)	21.03	9,099	23.13	9,383	19.03	7,354	25,836
Warm water fishing	46.15	19,968	48.35	19,615	42.56	16,446	56,029

Derived from Tables 3-A, 3-C, 3-E of *Hunting & Fishing in New Hampshire*, prepared by George M. Reed and Carol Pierstorff for the New Hampshire Fish and Game Department; Concord, NH, 1978.

Table 4-6: Vermont Fishing Activity, 1975

ACTIVITY	Resident			Non-Resident			TOTAL	
	Number of Participants	Average Number of Days	Projected Total # of Days	Number of Participants	Average Number of Days	Projected Total # of Days	Total Number of Participants	Projected Total # of Days
Pond	68,355	12.4	847,602	32,226	9.6	309,370	100,581	1,156,972
Stream	64,280	16.6	1,067,048	32,425	9.8	317,765	96,705	1,384,813
TOTAL	—	—	1,914,650	—	—	627,135	—	2,541,785

Derived from Alphonse Gilbert, *Hunting and Fishing Expenditure Study*. Vermont Agricultural Experiment Station, University of Vermont, 1976.

Both the New Hampshire and Vermont studies calculated the value of fishing to the state economy based upon the amount of money spent on fishing by license holders. The total amount spent in Vermont in 1975 was estimated at $46,179,663. and in New Hampshire in 1978 was estimated at $75,034,900. Tables 4-7 and 4-8 provide a breakdown of these figures.

Table 4-7: Projected Expenditures by Fishermen in Vermont, 1975

ACTIVITY	Resident (Thousand $)	Non-Resident (Thousand $)	Total (Thousand $)
Stream Fishing	9,618.12	8,623.01	18,241.13
Lake and Pond Fishing	14,733.92	13,204.67	27,938.59
TOTAL	24,352.04	21,827.68	46,179.72

Source: Alphonse Gilbert, *Hunting and Fishing Expenditures Study*, Vermont Agricultural Experiment Station, University of Vermont, 1976.

Table 4-8: Projected Expenditures by Fishermen in New Hampshire, 1975

ACTIVITY	Resident (Thousand $)	Non-Resident (Thousand $)	Total (Thousand $)
Trout Fishing	26,712.7	14,951.8	41,664.5
Salmon Fishing	4,975.9	3,737.9	8,713.8
Lake Trout Fishing	4,975.9	3,737.9	8,713.8
Warm Water Fishing	9,428.0	31,942.4	18,942.8
TOTAL	46,092.5	54,370.0	78,034.9

Source: George M. Reed and Carol Pierstorff, *Hunting and Fishing in New Hampshire*, prepared for the New Hampshire Fish and Game Department, Concord, NH, 1978.

Potential for Conflict

Hydropower facilities can restrict flow and destroy habitat and, to a lesser extent, can hinder seasonal migration. Due to the greater environmental changes that accompany repair of breached dams or the construction of new dams, conflict is more severe when sites in these categories are developed. It is important to note that cold water fisheries are in great demand, and that given this demand, any river containing cold water species has some importance and hence, some level of conflict is possible if hydropower facilities are developed.

In New England 106 sites with a potential combined capacity of 212 Mw and a total annual energy of 1,300,946 Mwh are located on segments identified as supporting highly-valued cold water fisheries (see Table 4-9). These sites would account for 36% of the total energy potentially available in the 6 states. In New England, 25% of the existing sites, 32% of the breached sites, and 52% of the new sites may conflict with significant cold water fishery resources identified by this study.

Table 4-9: Potential Conflict between Hydropower Facilities and Significant Cold Water Fisheries

	Existing Dams			Breached Dams			New Sites		
	Number of Sites	Capacity (Mw)	Annual Energy (Mwh)	Number of Sites	Capacity (Mw)	Annual Energy (Mwh)	Number of Sites	Capacity (Mw)	Annual Energy (Mwh)
CT	9	7.3	44,953	1	1.5	9,106	2	8.2	50,405
ME	16	19.8	118,182	6	21.7	133,273	13	80.6	494,337
MA	12	5.9	36,093	1	0.4	2,269	1	4.2	25,687
NH	22	18.2	111,333	3	3.8	23,069	2	18.9	115,772
RI	4	0.5	3,311	—	—	—	—	—	—
VT	8	11.0	67,464	1	0.3	1,766	5	10.4	63,926
New Eng.	71	62.7	381,336	12	27.7	169,483	23	122.3	750,127

	Total Conflict with Major CW Fisheries			Total Potential Hydropower Output in State		
	Number of Sites	Capacity (Mw)	Annual Energy (Mwh)	Number of Sites	Capacity (Mw)	Annual Energy (Mwh)
CT	12	17.0	104,464	39	37.1	227,730
ME	35	122.1	745,792	109	315.1	1,931,898
MA	14	10.5	64,049	55	57.8	354,705
NH	27	40.9	250,174	96	122.7	752,623
RI	4	0.5	3,311	22	10.1	62,191
VT	14	21.7	133,156	43	41.4	253,993
New Eng.	106	212.7	1,300,946	364	584.2	3,583,140

Note: Capacity was estimated on the basis of a 70% plant factor.

Recreational and Scenic Rivers

Background

With the exception of a state-wide program in Massachusetts and the Allagash Wilderness Waterway managed by the state of Maine, programs concerned specifically with the management of scenic and recreational rivers are federally sponsored. The principal management program is the Wild and Scenic Rivers Program, but regulatory protection is also provided by the Federal Power Act.

In 1968, Congress passed the National Wild and Scenic Rivers Act (PL 90-542) to preserve selected, free-flowing rivers throughout the nation. Water projects, including the construction of new dams, are prohibited on segments designated in accordance with this law, or on segments being studied for eventual designation.

In New England, only one river, the Allagash in Maine, has been designated under the federal program. Three other river systems, the Shepaug and Housatonic in Connecticut, and the West and East Branches of the Penobscot in Maine are now under study. The study period for the Penobscot will end in October 1981; prohibition of the construction of new dams will automatically end at that time. Study status for the Shepaug and Housatonic will be lifted on October 2, 1982.

Whitewater rafting on the West Branch of the Penobscot [illegible]
Northern Whitewater Expeditions, Inc.

One hundred and forty-four other river segments in New England have also been identified on an inventory prepared by the Heritage Conservation and Recreation Service as potential candidates for national designation because of their high scenic or recreational value. Under a directive issued by President Carter in 1979, all federal agencies were directed to review any federal actions (e.g., the issuance of a license) affecting proposed projects on these segments to insure that any possible adverse effects that such projects might have on scenic and recreational values were avoided or mitigated. With the recent change in administration and a shifting of HCRS program responsibilities to the National Park Service, the status of this directive is unclear. However, the inventory made by HCRS has served to draw attention to the most important scenic and recreational river segments in the region.

The Massachusetts Scenic and Recreational River Act (MGL Ch. 21, s. 17b) grants the Commissioner of the Department of Environmental Management the authority to issue orders designed to protect the environmental and scenic integrity of the outstanding river resources of the Commonwealth. The state has inventoried over 1,700 river miles and has proposed 50 segments for inclusion in a statewide system of scenic and recreational rivers. To date, only the North River (Plymouth County) and a few small streams on state land are protected under the state program.

New Hampshire's Office of State Planning has inventoried its rivers for significant wild, scenic, or recreational segments. In 1977, 7 wild, 29 scenic, and 31 recreational segments were identified and proposed for further study. New Hampshire does not have a river protection statute at this time.

There is no single statute or program which specifically protects white water or flat water recreation opportunities. Section 10 of the Federal Power Act recognizes the need to balance the public interest in the nation's waterways among several uses, including recreation. There is a substantial precedent for compliance with this statute as administered by the FERC. The Seventh U.S. Circuit Court, for example, in the case of *Namekagon Hydro Company vs. F.P.C.* (216 F.2d 509), upheld the FPC's decision to deny a license on the grounds that the unique recreational features of the river were of greater public benefit than construction of a power dam. In the case of *Udall vs FPC* (387 U.S. 428, 1967) the Supreme Court advised FERC to consider all relevant issues related to the public use of a waterway. The Court also directed FERC to consider all alternatives including the "no-build" alternative and whether the waterway would be of more benefit to the public if it remained wild, scenic, available for fishing and/or available for recreation.

Location and Significance of River Segments of Scenic and Recreational Value

River segments of high scenic or recreational value have been indicated on the NERBC 1:500,000 scale maps (see maps accompanying this report). Segments are classified as follows:

- *Segments of high aesthetic, historic, geologic or ecological value*: These are river reaches which have unique or outstanding features of one or more of the four types.
- *White water recreation segments*: These are river reaches which currently have sufficient flow, gradient, and bed conditions to provide opportunities for white water canoeing, kayaking or rafting. These reaches are rated on a scale ranging from "easy" (2) to "very difficult" (5).
- *Flat water canoeing segments*: These are river reaches used for long distance canoe trips.

Scenic and recreation values are often intangible and are not easily quantified or assessed. The segments mapped by NERBC were identified through a process in which constituency groups were asked to evaluate the 144 scenic segments listed in the inventory prepared by HCRS and 100 recreational segments compiled by NERBC.

In compiling its inventory, HCRS specified that qualifying segments must be:

- at least 5 miles in length;
- free-flowing and not significantly altered by channelization or construction of dikes, levees, dams or other structures;
- largely undeveloped, with shorelines or watersheds in essentially primitive condition, except for dispersed small communities, clustered residential development or agricultural land uses; and
- within or adjacent to an area that contains resources of "outstandingly remarkable" value, including geological, ecological, cultural, historic, scenic, botanical or recreational features.

Free flowing, scenic river segment. Photo: Bob Sabbatini

The NERBC listing of recreational segments was compiled using published guides of white water and flat water rivers (see Appendix D). The guides were comprehensive in their listing of rivers, but provided no indication of the extent of use of a river or other information which would reveal the importance of the river for recreational purposes. These two lists were then distributed to relevant state agencies, environmental organizations, commercial river guide services, and organized boating groups for their comments. Respondents were asked to identify those segments of highest scenic and or recreational value, to provide comments supporting the preservation of these segments in their present form, and to provide any other pertinent data such as the extent of use or information regarding flow.

The result of this process is a refined list of the 54 scenic and recreational river segments generally considered to be the most highly valued segments in the region*. All segments on this list received support from at least four of the following sources:

- State river program inventories
- Statewide environmental organizations
- Significant local protection interest
- Regional recreation or environmental organizations
- Recreational experts
- Organized boating interests
- Commercial outfitters

These 54 segments total about 1,500 miles in length, as compared to the 3,500 miles of rivers listed in the original HCRS inventory. They represent less than 25% of the total miles of mainstem rivers and tributaries in New England. As shown in Table 4-10, over one-third of this 1,500 miles of scenic segments is located in Maine, with over one-half the remainder located in Vermont and New Hampshire.

Table 4-10: Distribution of Scenic and Recreational River Segments

STATE	# Miles of Scenic Segments	# Miles of White water Segments	Difficulty of White water Segments: Class 2	Class 3	Class 4	Class 5
CT	159.25	31.00	20.75	9.00	—	—
ME	642.50	100.00	60.50	23.25	10.00	6.00
MA	180.70	75.00	21.85	42.60	9.50	—
NH	221.95	115.00	29.75	36.00	29.20	—
RI	39.50	.50	.50	—	—	—
VT	202.00	20.00	16.50	3.25	—	—
Inter-State	37.00	—	—	—	—	—
TOTAL	1482.50	341.50	149.85	114.10	48.70	6.00

* Appendix D provides information on each segment identified in the evaluation of scenic/recreational rivers as well as a listing of constituency groups participating in the assessment. Where available or applicable, information is provided on the significant features of each stretch, including the quantity of flow needed for white water recreation, and other comments relative to the uniqueness or regional significance of the stretch.

White water segments, which in many cases coincide with scenic segments, total less than 350 miles, or less than 5% of the region's total miles of streams. These relatively scarce segments are located primarily in New Hampshire and Maine, and on tributaries of the Connecticut River in Massachusetts.

Class 4 and 5 waters, the most challenging and difficult, are extremely scarce — only 6 miles of Class 5 white water (located on the Kennebec and West Branch of the Penobscot River in Maine[1] exist in New England.

Ideally, the significance of these river segments should be measured not only by their uniqueness or scarcity, but by the extent to which they are used by recreationists, and by the importance of these recreational activities to state and local economies. However, data on the recreational use of rivers is very limited, and participation in recreational activities is as much a function of availability of access to rivers as it is a function of the demand for such activities. Predicting future recreational demand and usage is perhaps as precise as predicting future energy demand.

What is clear, however, is that with the success of pollution abatement efforts and increases in available leisure time, interest in recreational river activities is steadily increasing. As an example, whereas only two companies were manufacturing canoes in the region ten years ago, there are now twelve. Two of these companies, Old Town Canoe Company and Mad River Canoe Company report sales increases of 25% in the last two years. As a second example, it is estimated that over 12,000 people will enjoy white water rafting in the Kennebec Gorge and on the West Branch of the Penobscot River in 1981, at a per capita cost of $50 - $70.

Potential for Conflict with Hydropower

To identify the extent to which hydropower development might compete with either recreational river use or protection of scenic values, the locations of potential hydro listed in Tables 2-2 and 2-3 were compared with the scenic and recreational river segments. The results of this comparison are displayed in Table 4-11.

The potential for conflict between the development of hydropower at existing dams and the protection of scenic and recreational river segments is minimal. Only 31 out of 320 existing dams shown on the maps are located on or immediately above scenic or recreational segments. If these sites are operated in a strictly run-of-river mode, with little or no diversion of stream flow, there would be no conflict at all.

The potential for conflict between new dam development and maintenance of scenic or recreational river segments is much greater. Twelve of 31 potential new sites in Maine, for example would require flooding of highly valued recreational or scenic segments. The aggregate capacity of these potential sites exceeds 80 Mw at a 70% plant factor and 160 Mw if the sites were developed at 40% plant factor.

Table 4-11: Analysis of Conflict Between Potential Hydro Sites and Important Scenic and Recreational Rivers in New England

STATES	No. of Important Segments	No. of Miles of Important Rivers	No. of Potential Existing Sites on Segments	Combined Capacity Existing Dams (Mw)	Annual Energy Existing Dams (Mwh)	No. of Potential Breached Dams on Segments	Combined Capacity Breached Dams (Mw)	Annual Energy Breached Dams (Mwh)	No. of Potential New Sites	Combined Capacity New Sites (Mw)	Annual Energy New Sites (Mwh)
CT	5	159.25	9	8.0	49,356	1	1.5	9,106	2	8.2	50,402
ME	14	642.50	6	7.9	49,286	1	0.5	3,305	12	93.0	498,000
MA	9	180.70	1	0.5	2,815	1	1.5	9,161	1	4.2	—
NH	18	221.95	5	5.4	38,110	2	3.1	18,540	—	—	—
RI	2	39.50	5	0.8	4,801	—	—	—	—	—	—
VT	6	202.00	2	1.7	9,984	—	—	—	2	5.3	32,634
Interstate	1	37.00	—	—	—	—	—	—	—	—	—
TOTALS	55	1,482.90	28	19.4	154,360	5	6.6	40,113	14	110.7	581,550

Chapter V: Analysis of Potential Conflicts at New Dams

Introduction

Development of new hydropower dams has the potential to create more severe environmental impacts and conflicts with competing uses than has the rehabilitation of existing dams. There are several reasons for this:

- new dams will create impoundments which may innundate existing development, agricultural and forested lands, or habitat supporting plant and wildlife populations;
- new dams may create obstacles to fish passage and to recreational use of rivers;
- new dams may alter the natural or pre-existing flow regime, and thereby affect both up and downstream water uses.

As noted in Chapter II, NERBC identified 44 new sites as potentially feasible for hydropower development. Using information available from state and federal agencies, NERBC surveyed the 44 hydropower sites to identify potential impacts on land use, endangered species, historic and archeological sites, anadromous fish, and important recreational and scenic river segments. The sites in Maine were also evaluated for their potential to affect state Critical Areas for which a registry is maintained by the State Planning Office and protection zones designated by the Land Use Regulation Commission (LURC) in the unorganized townships.

Table 5-1 presents a summary of the potential impacts at the 44 new dam sites. This information is provided as an overview of potential conflicts caused by new dam development. It can also be used by prospective hydro developers and regulatory agencies as a guide to potential problems at any one site, although detailed field analysis is required to more precisely assess the magnitude and significance of potential problems. The most significant of these impacts are discussed below.

Impacts on Land Resources

Development of the 44 selected new dam sites would create impoundments which collectively would inundate 12,520 acres of land (see Table 5-2). Development of the 31 sites in Maine also would inundate 10,495 acres or 84% of the total. Inundation of these lands would constitute an *irreversible commitment* of finite productive resources, and in many cases, the effects of such innundation could not be mitigated. The extent of potential effects on various land-related resources is summarized below.

Impacts on Productive Land Uses

Forested Land. Forests cover 31.5 million acres, or about three-quarters of New England's land area. Over half of the land which could be innundated by the development of the currently developed sites is forested. About 7,055 acres, comprising 0.02% of the region's forest lands, would be *innundated* if all of the new dams were constructed. About 85% of this total is located in Maine, and the remainder is located in Vermont (7%), Connecticut (5%), New Hampshire (2%), and Massachusetts (1%) (see Table 5-2). Innundation of forest lands would occur at 30 sites which have an aggregate capacity of 179 Mw,* or 66% of the total capacity of undeveloped sites. Twenty three of these sites, comprising 51% of the total capacity, are located in Maine. Over half of the total innundation of forest land would occur at 8 of the largest sites in Maine, representing 22% of the total capacity at undeveloped sites.

Agricultural Land. About 9% of the land which would be innundated by new dams is agricultural land, primarily crop and pasture. A total of 1,165 acres of agricultural land would be inundated, representing about 0.04% of the region's 2.6 million acres of crop and pasture land. About half of the affected agricultural land is located in Maine, 38% is in Vermont, and 15% is in New Hampshire (see Table 5-2). Agricultural land would be innundated at 13 of the 44 new hydropower sites, representing 56 Mw, or 20% of the combined new site capacity. Over 55% of the innundated agricultural land occurs at just 3 sites representing 5% of the total capacity at all new sites.

Mineral Extraction. Two sites, 1 in Connecticut and 1 in Vermont, would innundate 45 acres of quarries or gravel pits. These 2 sites have a combined capacity of 6.3 Mw, or 2% of the total capacity at all of the potential new sites studied.

Impact on Wildlife Habitats

Wetlands. Wetlands are important wildlife habitats and also serve as natural flood retention areas. Eight new hydropower sites, all in Maine, would innundate a total of 3,635 acres of wetlands, representing 0.2% of the fresh water wetlands in the state. These 8 sites have a combined capacity of 54 Mw, or 20% of the undeveloped site capacity in New England. Three of the sites, representing 5% of the total capacity, would be responsible for 85% of the wetlands innundation. Six of the sites would affect wetlands which are designated as protection subdistricts by the Maine Land Use Regulation Commission (LURC).

Endangered Species. Several of the undeveloped sites in Maine have the greatest potential for affecting habitats important to endangered plants. Fourteen known rare plant sites could be affected by 5 new dams with a combined capacity of 31 Mw, or 11% of the potential capacity of the sites studied. Two of these sites are registered with the Maine Critical Areas Program. In addition, 7 new dams could affect 14 possible sites of rare plants. These 7 new dams have a capacity of 43 Mw, or 16% of the total.

* Capacities were estimated on the basis of a 70% plant factor. Development of the sites at a lower plant factor would provide greater installed capacity. Development at a 40% plant factor, for example, would increase the capacity from two to two and one half times that developed at a 70% plant factor.

Table 5-1: Potential Impacts at New Dam Sites

Site No.	Project Name	Basin	Capacity (Mw)*	Gross Head (Ft)	Land Inundated (Acres)	Land Uses: Forested (Acres)	Land Uses: Agriculture (Acres)	Land Uses: Mineral Extract (Acres)	Wetlands (Acres)	Habitat: Endangered Species Sites: Animals Known	Habitat: Endangered Species Sites: Animals Poss.	Habitat: Endangered Species Sites: Plants Known	Habitat: Endangered Species Sites: Plants Poss.	Habitat: Deer Yards
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Maine														
99004	Seven Islands	St. John	7.4	33	1000	375			625					
99007	Big Black Res.	St. John	2.1	25	840	340			500					
99022	Mile 1 Fish R.	St. John	3.2	23	35	35						1		
99023	Masardis	St. John	3.0	33	1100	900	50		150			4		1
99024	Washburn	St. John	5.5	22	305	275			30			5		
99154	Pond Pitch	Penobscot	2.9	31	185				185					
99163	Bear Rapids	Penobscot	4.5	30	620	590			30					
99171	Sourdnahunk	Penobscot	12.2	53	400	400				BE	PF			
99172	Pockwockamus	Penobscot	11.9	33	750	560			190					
99177	Gordon Falls	Penobscot	4.3	20	50	50								
99178	Stratton	Penobscot	6.2	27	70	70								
99179	Winn	Penobscot	3.7	5	10						BE		1	
99180	Mohawk Rapids	Penobscot	5.4	7	60					BE				
99187	Marsh Island	Penobscot	17.1	15	30					BE			1	
99190	Basin Mill	Penobscot	5.9	5	80								4	
99200	Above Foxcroft	Piscataquis	1.2	20	100	75	25						3	
99207	Campbell Rips	Piscataquis	4.2	20	200	150	50							
99305	Above Indian Pond	Kennebec	4.4	23	70	70								1
99307	Steepside	Kennebec	12.7	53	170	170						3		1
99309	Grand Falls	Kennebec	2.9	35	2025	200			1825					
99313	Poplar Falls	Kennebec	15.4	120	340	290			50					
99314	The Forks	Kennebec	4.9	13	85									
99315	Carrying Place	Kennebec	12.6	20	475	475								
99318	Above N. Anson	Kennebec	6.5	15	625	325	300						1	
99319	South Madison	Kennebec	6.4	13	20							1	2	
99350	Above Phillips	Sandy	.7	30	25	25								
99452	U. Umbagog Lake	Androscoggin	3.5	40	100	100								
99454	Philbrook	Androscoggin	4.2	15	300	300					PF			
99462	Dixfield	Androscoggin	4.9	13	75	75								
99471	Donovan Rips	Androscoggin	6.2	11	350	175	125		50	SS				
99555	Steep Falls	Saco	2.5	10	**								2	
New Hampshire														
90327	Woodsville	Connecticut	1.7	27	30	10	20							
90985	Hart Island	Connecticut	21.0	28	275	125	150							
90986	Chase Island	Connecticut	18.3	24	50									
92706	Moores Falls	Merrimack	17.1	35	175						SS			
Vermont														
93351	Johnson	Lk. Champlain	1.1	23	30		30							
94600	Lyndonville	Connecticut	1.7	47	70		50	20			PF			
98380	Locust Creek	Connecticut	1.7	39	210		210							
98383	West Hartford	Connecticut	3.6	33	410	350	60				PF			
99413	Williamsville	Connecticut	2.2	37	135	45	70							
99850	Brattleboro	Connecticut	1.7	23	125	100	25				PF			
Connecticut														
99719	Kent Furnace	Housatonic	4.6	40	350	325		25						
99722	Boardman	Housatonic	3.6	23	90									
Massachusetts														
99854	Meadow	Deerfield	4.2	40	75	75				SS				

*Computed at 70% Plant Factor **Too Small to Map BE Bald Eagle PF Peregrine Falcon SS Shortnosed Sturgeon

Cultural				Maine Critical Areas		LURC Protection Zones				Anadromous Fish			Fresh-water Fish	Scenic Recreational			
Historic Sites		Archeological Sites								Up-stream	Down-stream			Up-stream	Down-stream		Site No.
Known	Poss.	Known	Poss.	Reg-istered	Poten-tial	P-FW	P-RR	P-WL	P-UA	Seg-ments	Seg-ments	% D.A.	Seg-ments	Seg-ment	Seg-ment	% D.A.	
16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33
1(E)		12					1(P)	1						SR			99004
		2(1E)					1(P)	1						S			99007
				1									1				99022
		1	1			1		1		P							99023
										P							99024
					2		1(P)	1			E	100	1	SR			99154
							1(P)			E			1	SR			99163
					1	1	1(P)						1	SR			99171
					2		1(P)	1						SR			99172
	1				1					E							99177
	1				1					E							99178
	1									E							99179
		1								E							99180
		2								E							99187
										E							99190
										E							99200
		3								E							99207
					1	1							1		SR	90	99305
				1		1			1				1	SR	SR	64	99307
						1		1						SR	SR	22	99309
					1		1							SR	SR	34	99313
													1	SR			99314
							1						1	SR			99315
2(1NR)		2(1NR)								P			1				99318
		2(1NR)		1						P			1				99319
											P	86					99350
			1		1								1	R			99452
													1				99454
			1							P							99462
	1	2								R							99471
		1			1					P			1				99555
			1							R			1				90327
			1							R							90985
1(E)			1							R							90986
		1								R			1				92706
													1				93351
										P							94600
										R			1	SR			98380
										R			1	SR			98383
										E			1				99413
										E			1				99850
														SR			99719
														SR			99722
	1		1										1	SR			99854

(NR) National Register (E) Eligible (P) Potential

E Existing Run
R Run Under Restoration
P Potential Run

S Scenic Segment
R Recreational Segment

Table 5-2: Land-Related Impacts of New Site Development

	Number of sites	Capacity (Kw)	Land Inundated	Land Uses: Forested Acres	Land Uses: Agric. Acres	Land Uses: Mineral Extract.	Habitat: Endangered Species: Wetlands Acres	Plants Known	Plants Poss.	Animals Known	Animals Poss.	Deer Yards
ME	31	188,578	10,495	6,025	550	—	3,635	14	14	4[1]	3[1]	3
NH	4	58,179	530	135	170	—	—	—	—	—	P[2]	—
VT	6	12,095	980	495	445	20	—	—	—	—	—	—
CT	2	8,220	440	325	—	25	—	—	P[2]	—	P[2]	—
MA	1	4,189	75	75	—	—	—	—	—	1	—	—
TOTAL	44	271,261	12,520	7,055	1,165	45	3,635	14	14	5	3	3

	Cultural Resources: Historic Known	Historic Poss.	Archeological Known	Archeological Poss.	Maine: Critical Areas	LURC Zones
ME	3	2	27	3	14	29
NH	1	—	1	3	—	—
VT	U[3]	U[3]	U[3]	U[3]	—	—
CT	U[3]	U[3]	U[3]	U[3]	—	—
MA	—	P[2]	—	P[2]	—	—
TOTAL	4	2	29	6	14	29

[1] In vicinity of project area
[2] Potential for undetermined number of sites
[3] *Data for these states unavailable at time* of publication

Endangered animals potentially affected by the new dams include the peregrine falcon, the bald eagle, and the shortnose sturgeon. Five new dam sites in Maine and Vermont are located near areas once used as nesting sites by the peregrine falcon and which may be used in the peregrine restoration program, although none of the dams would affect existing peregrine falcon nesting sites. The 5 dams have an aggregate capacity of 23 Mw, or 8% of the total. Three new dam sites in Maine are near active bald eagle nests. Two new dams in Maine could affect trees used by bald eagles as perches in winter. These new dams have a capacity of 39 Mw, or 14% of the total. Two sites, 1 in Massachusetts and 1 in New Hampshire, may affect habitat of the shortnose sturgeon. These sites represent 21 Mw, or 8% of the total capacity at new dams. In addition to the sites listed above, 4 sites in New Hampshire and 2 in Connecticut are located in areas with high potential to support endangered species.

Deer Yards. Deer yards, used for food and cover in the winter, would be affected by 3 new dams in Maine. These dams have a capacity of 20 Mw, representing 7% of the total. All 3 deer yards are part of LURC protection subdistricts.

The above summary of potential impacts on habitats is based on information readily available from state and federal agencies. Actual impacts on habitats are site specific and cannot be adequately assessed without a thorough on-site survey.

Historic and Archeological Resources

Historic and archeological sites are frequently located in river valleys making them susceptible to innundation by new dam developments. Four known historic sites would be affected by 3 new dams in New Hampshire and Maine. One of these sites is listed on the National Register of Historic Landmarks and 2 others are eligible for registration. The 3 dams have a capacity of 32 Mw, or 12% of the total. In addition, 3 areas which are likely to be considered with historic sites could be affected by 5 new dam developments in Maine and Massachusetts.

Twenty-nine known archeological sites, 28 in Maine, and 1 in New Hampshire, could be affected by 11 of the new dams studied in those states. Two of the sites are listed on the National Register, and 1 is eligible for listing. The 11 dams have a combined capacity of 78 Mw, representing 28% of the total. Seven other areas with high potential for archeological sites could be affected by 7 new dams in Maine, New Hampshire and Massachusetts.

The above summary is based on information available from state agencies. Many areas are not well surveyed, consequently the full impact of constructing any of the new dams cannot be determined without studies of specific sites.

Maine State Resource Programs

There are two resource management programs in Maine which address some of the resources discussed above. These are the Critical Areas Program and the Land Use Regulation Commission. The possible impact of new hydropower development on resources managed by these programs is summarized below.

Critical Areas. Maine's Critical Areas Program has inventoried important biologic, geologic, and hydrologic features in the state. Three hundred and thirty-six sites have been registered as critical areas. The inventory includes 185 botanical and zoological areas, some of which are sites of endangered species. Also registered are 43 waterfalls and 15 gorges. In addition, 40 white water rapids and 3 waterfalls have been recommended for registration.

The construction of dams at 3 of the undeveloped sites would affect registered critical areas which include 2 waterfalls and 2 rare plant habitats. These sites have a combined capacity of 22 Mw, or 8% of the total capacity of the new sites studied and 12% of the new site capacity in Maine. In addition, there are nine areas which have the potential to be designated as critical areas; these include 8 waterfalls and 3 rapids. These 9 areas could be affected by 9 hydro sites representing 23% of the aggregate new site capacity and one-third of the capacity in Maine. One gorge (Ripogenus), which has been nominated for critical area registration, would be affected by development of an undeveloped site.

LURC Protection Subdistricts. Maine's Land Use Regulation Commission (LURC) has responsibility for regulating development in Maine's unorganized territories, which comprise 10.5 million acres or roughly one-half of the state's land. LURC has developed a comprehensive land use plan which includes zoning regulations for use and development of these lands. The zoning regulation includes a category for protected resources such as wetlands, fish and wildlife areas, recreation areas, and unusual areas.

Sixteen of Maine's 31 undeveloped sites fall within LURC's jurisdiction. New dams at 12 of these sites would affect 1 or more of the resource protection zones mentioned above. At these 12 sites, 5 fish and wildlife zones, 6 wetlands zones, 2 recreation protection zones, and 1 unusual area zone would be affected. In addition, 6 proposed resource protection or recreation protection zones might be affected. These 12 sites have a combined capacity of 93 Mw, or one-third of the total capacity of the new dams studied, and nearly one-half of the potential capacity in Maine.

Impacts on Water Resources

Anadromous Fisheries

Anadromous fish runs could be affected at 26 of the 44 undeveloped sites studied. These 26 sites have a capacity of 160 Mw representing 58% of the total capacity of the 44 sites. Existing runs and runs under restoration could be affected by 19 new dams representing 48% of the total capacity of the 44 sites. These sites are distributed among the states as follows:

	Number of Sites	Capacity (Mw)	Percentage of Total Capacity of New Dams Studied
Maine	11	62	23%
New Hampshire	4	58	21%
Vermont	4	9	3%
TOTAL	19	129	48%

Twelve of the anadromous fish runs are existing runs; 7 are runs currently under active restoration.

Fresh Water Fisheries

Important, cold water, fresh water fisheries could be affected by 21 undeveloped dams with a combined capacity of 112 Mw, representing 41% of the capacity at dams studied. These new dams and their capacities are distributed among the states as follows:

	Number of Sites	Capacity (Mw)	Percentage of Total Capacity of New Dams Studied
Maine	13	78	29%
New Hampshire	2	19	7%
Vermont	5	10	4%
Connecticut			
Massachusetts	1	4	1%
TOTAL	21	112	41%

Construction of dams at thirty-two of the 44 undeveloped sites could have an impact on either fresh water or anadromous fisheries. These 32 sites represent 208 Mw, or 77% of the total capacity of the undeveloped sites studied.

Scenic and Recreational Rivers

Nine scenic and recreational river segments could be affected by 17 new dams representing 111 Mw, or 41% of the total capacity of the sites studied. These dams and their capacities are distributed as follows:

	Number of Segments	Number of Dam Sites	Capacity (Mw)	Percentage of Total Capacity of New Dams Studied
Maine	6	12	93	34%
Vermont	1	2	5	2%
Connecticut	1	2	8	3%
Massachusetts	1	1	4	2%
TOTAL	9	17	111	41%

Construction of dams at 14 of these 17 sites would affect segments with both scenic and recreational values; construction of dams at 2 sites would affect only scenic river segments, and construction of a dams at 1 site would affect a recreational river segment.

The recreational river segments include both flat water and white water The white water is classified according to difficulty, with Class V being the most difficult. The distribution of the impacts of the construction of new dams among flat water and white water segments is as follows:

	Number of Segments	Number of Dam Sites	Capacity (Mw)	Percentage of Total Capacity of New Dams Studied
Flatwater	1	1	5	2%
Whitewater				
Class II	2	3	13	5%
Class III	4	7	47	17%
Class IV	1	1	4	1%
Class V	2	3	37	14%

The above table shows that the best white water segments (those in classes III, IV and V) would be affected by 11 dams representing nearly one-third of the total capacity at the new dams studied.

Aggregate Impact on Fisheries, Recreation, and Scenic Reaches

Thirty-nine of the 44 dams proposed at undeveloped sites could affect either fisheries or scenic and recreational rivers. These 39 sites have a capacity of 256 Mw or 94% of the total capacity of the undeveloped sites studied. Only five sites — 4 in Maine and 1 in Vermont — would not have a major impact on fisheries or recreational resources.

Downstream River System Effects

The discussion above has focused on conflicts which may occur immediately above or below a dam site. Depending on the way in which a hydro facility is operated and the amount of a basin's drainage area controlled by the facility, flow related effects may or may not occur further downstream. In columns 28 and 32 of Table 5-1 the percentage of basin drainage area above anadromous fish and recreational river segments which is controlled by each site is shown. Sites with the capability to regulate flow from a large proportion of the drainage area above the fishery or recreation segments may cause considerable effects on these resources if operated in other than a run-of-river mode.

Flat water touring in Massachusetts. Photo: Bob Sabbatini

Chapter VI: Conflict Resolution

Introduction

Development of many of the potentially feasible hydropower sites in the region will involve diversions of stream flow and/or be located on river reaches used or valued for other purposes. Development of hydropower sites may jeopardize these competing uses or values unless mitigation measures are incorporated into project design and operation. The need for mitigation, as well as the extent of the measures required, will undoubtedly cause disputes in the development process.

Many disputes will be resolved by negotiations, conducted within the context of rapidly changing political and regulatory processes. This chapter describes some of the important elements of the process of negotiation: the basic legal framework within which negotiation will occur; some of the tools available to aid in the understanding of opposing positions and perspectives; the feasibility for accommodating the needs of some competing uses in the design and operation of hydro facilities and finally, some alternatives which avoid conflict altogether.

No attempt is made to judge among competing values or to weigh the possible benefits of alternate courses of action. Many values competing with hydro are not quantifiable in economic or other terms, and even some aspects of hydropower are similarly not quantifiable. For example given the interconnected nature of the regional transmission system, it may not be possible to say precisely whether the residents in an area immediately adjacent to a new hydro facility will benefit from its development or whether the power will be transmitted elsewhere to offset the use of oil. Similarly, it is very difficult to determine how much canoeists are willing to pay for the pursuit of their activity or to what extent local economies benefit from an influx of recreationists.

Such value judgements can be made only on a site by site basis given the best information available at the time, and they are strongly influenced by political factors outside the realm of rational planning or analysis. In large part, the fate of each of the permit and license applications that have been submitted in the past year and a half will depend on these site specific value judgements and political factors.

The information presented in subsequent sections will show in part how decisions can be made in the context of a broad range of considerations rather than in the context of only one use, one activity, or one resource.

The Existing Legal Framework

The body of law and administrative procedure governing hydropower facilities reflects the need to reconcile the development of hydroelectric facilities with the needs of other flow dependent uses. The licensing procedure established by the Federal Power Act (16. U.S.C.E. 791 9-825 (r)) and administered by the Federal Energy Regulatory Commission

(FERC) regulates the construction, operation and maintenance of hydroelectric projects. Section 10A of the Act establishes a clear policy for reconciling hydropower with other river dependent uses and interests:

> ". . . the project adopted . . . will be best adapted to a comprehensive plan for improving or developing a waterway or waterways for the use or benefit of interstate or foreign commerce, for the improvement and utilization of water power development, and for other beneficial public uses, including recreational purposes . . ."

This general policy is augmented by other sections of the Act which require explicit consideration of the effects of a project on recreation, fisheries, and navigation, as well as on interstate commerce.

The FPA is the primary law governing hydropower and vests FERC with the authority to override state statutes and policies in the licensing process. The preemptive authority of FERC relative to other federal statutes and agency responsibilities is less clear and is currently the subject of considerable debate.* As a matter of practice, however, prospective developers are required by FERC to consult and demonstrate compliance with state and federal statutes governing water quality, recreation, and fisheries, and other aspects of water resources. This practice has been sanctioned by action of the courts.

The regulatory process is thus extensive. It is complicated by the need to consult with a large number of federal and state agencies, all of whom have different mandates for the regulation or management of public resources. The scope of the regulatory framework, and the complexity it poses for the prospective developer, has been investigated thoroughly in the past 3 years, with the work of Franklin Pierce Law Center comprising the most comprehensive survey of state and federal statutes**. For a thorough discussion, readers are advised to refer to the Franklin Pierce study.

To illustrate the extent of federal statutes and policies, Table 6-1 has been prepared. Provided herein are the prominent laws and an indication of the concerns covered and the nature of the authority conferred to the implementing agency. This matrix is provided as an illustration only.

State statutes and policies parallel the federal system, but constitute a separate series of regulations or requirements with which developers must comply. No attempt is made to illustrate the state systems since they vary immensely within New England and are comprehensively documented in the Franklin Pierce study.

* Legislation enacted subsequent to the Federal Power Act has created some uncertainty about FERC's preemptive authority. FERC has consistently asserted its authority in the licensing process and recently has sought amendments to the FPA to confirm its preemptive powers.

** Energy Law Institute, Franklin Pierce Law Center. *Legal and Institutional Incentives and Obstacles to Small Scale Hydropower in the Northeastern United States*

Table 6-1: Principal Statutes Relevant to Hydropower Development

STATUTES	Fisheries	Navigation	Power Generation	Recreation	Water Quality	Water Supply	Wildlife	Wild & Scenic Rivers Sites	Historic & Archeological	Plants	Wilderness
1. Federal Power Act											
16 U.S.C. s. 797(e)	R	R	R	R			R	R	R		
16 U.S.C. s. 803(a)	R	R	R	R			R	R	R		
16 U.S.C. s. 804		R									
16 U.S.C. s. 811	R	R									
2. Anadromous Fish Act											
16 U.S.C. s. 757(b)	C										
3. Fish & Wildlife Coordination Act											
16 U.S.C. s. 662(a)	C						C				
16 U.S.C. s. 663(a)	R						R				
4. Federal Water Project Recreation Act											
16 U.S.C. s. 406 1-12	P		P		P						
5. Federal Water Pollution Control Act, 33 U.S.C. (s. 1251 et seq.)											
Section 401 (33 U.S.C. 1341)	R			R	R	R	R				
Section 402 (33 U.S.C. 1342)	R			R	R	R	R				
Section 404 (33 U.S.C. 1344)	R		R		R	R	R				
6. Wild & Scenic Rivers Act											
16 U.S.C. s. 1278(a)								R			
16 U.S.C. s. 1278(b)								R			
7. Historic Preservation Act											
16 U.S.C. s. 469(a-c)									R		
8. National Environmental Policy Act											
42 U.S.C. s. 4321 et seq.	C	C	C	C	C	C	C	C	C	C	C
9. Endangered Species Act											
16 U.S.C. 1531 et seq.	R	C	C			C		R		C	
10. National Wilderness Preservation System											
16 U.S.C. s. 1131 et seq.											R
11. National Wildlife Refuge System											
16 U.S.C. s. 668 dd	R						R				
12. Public Utility Regulatory Policies Act of 1978											
16 U.S.C. s. 2705	R	R	R	R	R	R	R	R	R		
13. Energy Security Act of 1980											
P.L. 96-294 s. 408	R	R	R	R	R	R	R	R	R		

Notes: R Regulatory Power
C Consultation or comment power
P Policy Statement

The FERC application process is designed to expose potential conflicts associated with proposed projects. The application requires the preparation of several exhibits describing planned civil and mechanical works along with proposed operating procedures, financial arrangements, and schedules and management schemes for the construction, operation and maintenance of the facility. The exhibits also must include an assessment of environmental effects and competing uses as well as federal or state recommendations for mitigating the effects of any significant conflicts. The applicant is required to indicate its intent to accept, modify, or reject recommended mitigating measures.*

FERC publishes public notice of its receipt of an application in order to afford affected private and public interests an opportunity to comment on the proposed project. The public review generates the additional information which, together with the application, forms the principal basis for FERC's ruling on the license.

The Commission may take three actions: it may deny the application; it may award the license with conditions modifying the proposed plans; or, it may award the license without conditions. If the application is uncontested and the plans are judged adequate, FERC's process for issuing a license is perfunctory. But if, for example, there is a difference between the applicant's plans for measures to mitigate conflicts and the recommendations of an agency or the comments of an affected interest, FERC takes steps to reconcile the differences.

In resolving disputes over aspects of a project, FERC may direct an applicant to attempt to reconcile the differences with the dissenting agency or interest through negotiation and compromise. If this method fails, FERC may convene an administrative hearing to secure formal testimony from all parties to the dispute. On the basis of its evaluation of the evidence, the Commission issues a ruling dictating the means by which the dispute is to be resolved. FERC's ruling may take three forms:

- awarding the license with conditions provided to mitigate the seriousness of the dispute;
- awarding the license on the condition that the applicant will sponsor further studies designed to confirm or refute the need for further steps to reduce conclict;
- awarding the license with no conditions.

The principal guideline governing FERC's action on a dispute is the policy stated in Section 10A of the Federal Power Act, as noted above. Recreation, fish and wildlife management, or other uses will be made conditions of a license if they can be effectively represented as legitimate conditions necessary to achieve a project best adapted to a comprehen

* In recent months, the FERC has promulgated several regulations exempting projects from this procedure. See Appendix E for a summary of these exemptions, as well as a description of the preliminary permit and licensing process.

sive plan for development of the waterway, or if they are required by other federal agencies with statutory authority to do so.

The legitimacy of such concerns within the context of the licensing process is well established in principle at least by several laws and policies enacted by Congress or state legislatures. The application of these statutes to a particular site however, must be established on a case by case basis.

Understanding Competing Demands for Flow

One of the principal causes of disputes in the licensing process will involve competition for non-consumptive use of stream flow (instream flow competition). In the following sections, the flow characteristics of hydropower operations and the instream flow requirements of four major competing uses are described. Applicable flow criteria are presented together with summaries of flow policies or approaches currently being used by the various agencies involved in the maintenance or protection of instream flows in New England. These constitute the basis upon which state and federal agencies will recommend measures to mitigate adverse effects of hydropower development on instream flows.

Hydropower Operations

Stream flow regimes are generally depicted by use of a hydrograph such as the one shown in Figure 6-1. On the hydrograph, the quantity of flow in cubic feet per second (cfs) is shown for the various months of the year. The curve shown is typical of New England with a high spring peak

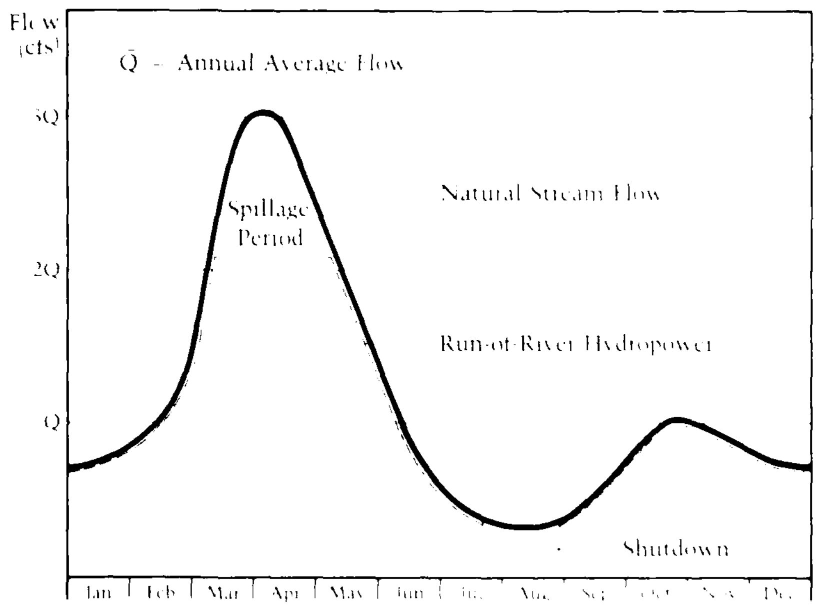


Figure 6-1: Hydrograph Showing Instream Flow Needs for Run-of-River Hydropower Operations

resulting from the winter snow melt and spring rains, and a low flow period which usually reaches a minimum in late summer.

A hydroelectric facility designed as an instantaneous "run-of-river" operation with no diversion of stream flow in a penstock or headrace canal has a hydrograph similar to that shown in Figure 6-1. Natural conditions are essentially unchanged. When flows exceed turbine capacity, the excess flows are spilled over the dam or spillway. When flows are less than the minimum required for efficient operation, the turbine(s) is shut off. At all times outflows at the base of the dam equal inflows to the impoundment above the dam. Turbine installations in New England typically have a maximum operating capacity of 115% of the installed design capacity and a minimum operating threshold of 30-40% of the installed design capacity.

Store and release operations, by contrast, require manipulation of natural stream flows on a daily, weekly, or seasonal basis, depending on the amount of storage available and the market conditions determining the load on the plant. A hydrograph for a weekly store-and-release operation is shown in Figure 6-2. In this situation, water is stored on weekends for release during the week when power demand is greater. This pattern is depicted by an oscillating hydrograph with about four cycles a month. A store-and-release operation also has a greater maximum turbine capacity and a non-existent or shorter period of shutdown during the drier summer months than does a run-of-river facility, since water can be stored to bring the amount available for periodic power generation up to the

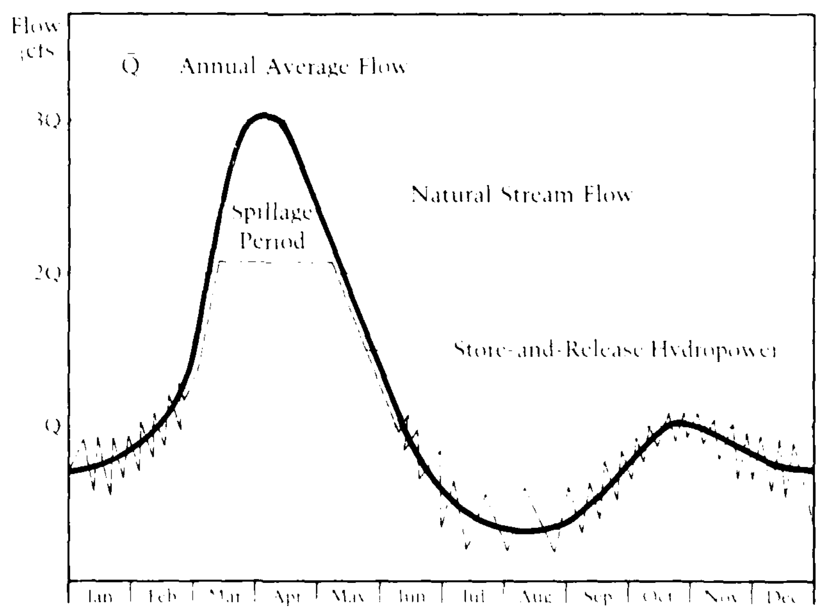


Figure 6-2: Hydrograph Showing Instream Flow Needs for Store-and-Release Hydropower Operations (Weekly Ponding)

minimum necessary to operate the turbine(s). Power supplied during periods of peak demand brings a greater economic return than power supplied during off-peak periods and thus there is greater incentive for constructing store-and-release operations.

On rivers where flow is already regulated for hydropower generation and other uses, the hydrograph will look quite different from the hydrograph of an unregulated river. If there is significant upstream storage, the hydrograph may have a more even and constant shape with the seasonal peaks flattened out. If the river is regulated to provide weekly storage, the hydrograph will look something like the oscillating curve shown in Figure 6-2.

Waste Assimilation

Stream water quality standards, developed by the states and approved by EPA, reflect public water quality goals. Recognizing that it would be impractical to maintain water quality standards under all conditions, the 7Q10 flow was adopted by most New England states (New Hampshire adopted 10Q20) as a measure of a relatively rare flow occurrence and as the threshold flow for water quality standards determinations. This flow standard is defined as the average seven day low flow with a 1 in 10 year recurrence interval. In other words, the standard designates a drought or low flow condition that has a ten percent chance of occurring in any one year.

Subsequent actions by municipalities, states and EPA to achieve the assigned water quality standards, including treatment plant design and permit development under the National Pollutant Discharge Elimination System (NPDES) program, have tended to reinforce the use of the 7Q10 as a design standard.

A 7Q10 flow is compared to a natural flow regime on the hydrograph shown in Figure 6-3. On an unregulated river, the 7Q10 flow will usually be about 10% of average annual flow. As shown in Figure 6-3, optimal conditions for providing good water quality may be considerably higher, and will depend on the characteristics of the stream and the pollution discharges into it.

In the past, this same standard has been applied to hydropower operations on licenses issued by the FERC as a minimum flow release required to sustain water quality standards, particularly if there are sewage treatment plants or other dischargers located downstream. 7Q10 has been applied in the past on both an instantaneous and an average flow basis.

More recently, EPA has recommended in its review of hydropower licenses that FERC require 7Q10 as an *absolute* minimum, but recognize that maintenance of such a minimal flow condition at all times is likely to place considerable stress on the aquatic environment of the stream. Instantaneous flows are now recommended as standard practice.

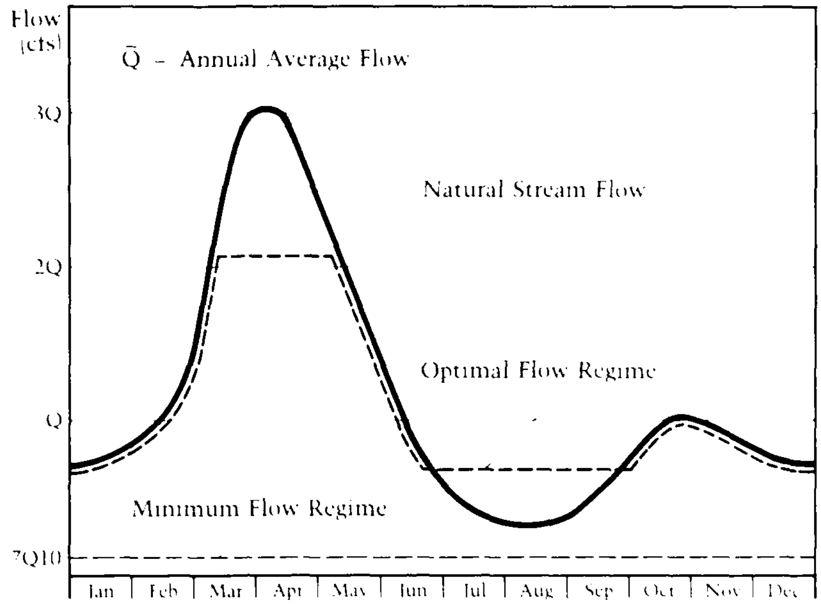


Figure 6-3: Hydrograph Showing Instream Flow Needs for Waste Assimilation

Fisheries

Critical factors affecting the survival, reproduction, and distribution of fisheries are the depth of the stream, the velocity of stream flow, the temperature of the water, and the substrate of the stream or river. All of these factors are directly related to the quantity and the timing of stream flow. Cover, an important aspect of the habitat of many species, is also related to stream flow in an indirect manner. For certain species of cold water fish, namely trout, it is well known what depth, velocity of stream flow, and other factors related to flow are required to maintain their habitats. Depth and velocity criteria are indicated in Table 6-2. Similar data for other important species such as Atlantic salmon are not well researched, primarily because the near elimination of this species from New England waters has precluded observation and analysis of their optimum and minimum habitat needs.

Flow regimes suitable for the maintenance of specific fisheries must be based on site specific evaluations of the relationship between flow and those physical and biological criteria which are important for the fishery. General methods for establishing flow regimes have been developed in the western United States, where the hydrogeologic conditions vary considerably from those of New England. For example, use of the "Montana" method suggests that 10% of the annual average flow is the minimum needed "just to keep things alive," while 30% to 40% of annual average flow is needed to maintain viable aquatic populations.

Table 6-2: Depth and Velocity Criteria for Some Species of Trout

Species	Range of Required Depth (feet)	Range of Required Velocities (ft sec)
Rainbow Trout		
spawning	0.5-1.4	0.9-2.7
juveniles	0.5-1.5	0.4-2.2
adults	greater than 1.4	0.5-2.2
Brown Trout		
spawning	0.3-10	0.5-2.2
juveniles	0.4-3.5	less than 1.5
Brook Trout		
spawning	0.2-1.0	0.1-1.5

Source: Vermont Agency of Environmental Conservation Water Resources Department

The "Incremental" method, also used primarily in the West, has typically led to the recommendation of a flow regime in the range of 40% - 60% of the annual average flow.

The New England Regional Office of the U.S. Fish and Wildlife Service (USFWS) has developed a method for establishing flow regimes designed to encourage releases that perpetuate indigenous aquatic organisms, including both fresh water and anadromous fish. Development of the policy was based on an analysis of historical stream flow conditions, given the lack of detailed knowledge of the specific physical and biological requirements of eastern species of fish. USFWS's method for establishing flow regimes presupposes that species native to given waters would have adapted themselves to the natural, seasonal alterations in the patterns of stream flow. The method used by USFWS to establish flow regimes is based on the fact that low flow conditions occurring during the month of August cause the most metabolic stress on aquatic organisms. The USFWS has concluded that stream flora and fauna have evolved to survive these periodic adversities without major population changes. Based on this conclusion, USFWS assumed that maintenance of a continuous minimum flow release equal to the August median is adequate throughout the year to protect aquatic species. If spawning and incubation activities take place in a river reach, releases equivalent to median flows during those seasonal periods are also recommended.

For free-flowing rivers where a minimum of 25 years of USGS gaging records exist at or near a project, the USFWS calculates flow regimes based on the gaging data. For regulated rivers (dammed or diverted upstream) or where flow records are inadequate, the USFWS recommends that the Aquatic Base Flow (ABF) release be equal to 0.5 cubic feet per second per square mile (cfsm) of drainage area. This recommendation applies during all times of the year unless USFWS finds that additional flows for spawning or incubation are needed. Flow releases of 1.0 cfsm in fall and winter, and 4.0 cfsm in spring will be recommended for spawning and incubation purposes.

As shown in Figure 6-4, the 0.5 cfsm August median generally equals about 26% of the annual average flow, while the 1.0 cfsm and 4.0 cfsm recommendations equal about 53% and 212% of annual average flow respectively.

The State of Vermont has developed a method for calculating minimum flow needs based on knowledge of the needs of certain species of trout (see Table 6-2). The method can be used to establish schedules of flow releases which must be maintained at hydropower projects. The method is applied to specific sites and it involves estimating the amount of useable area in a stream segment which is adequate for fish habitat, and then analyzing how different flow releases will affect the depth and the velocity of the water at selected cross sections of the stream segment. According to Vermont officials, use of this method to analyze the flow of an unregulated stream will generally result in a recommended minimum flow greater than the 7Q10 standard but less than the Aquatic Base Flow standard typically recommended by USFWS.

In addition to flow requirements needed to maintain or enhance fish populations, instream flow conditions affect the anglers and the quality of their fishing experience. The effect of flow variations on their experience is primarily determined by the form of recreational fishing pursued, e.g., wading, boat fishing, or bank fishing.

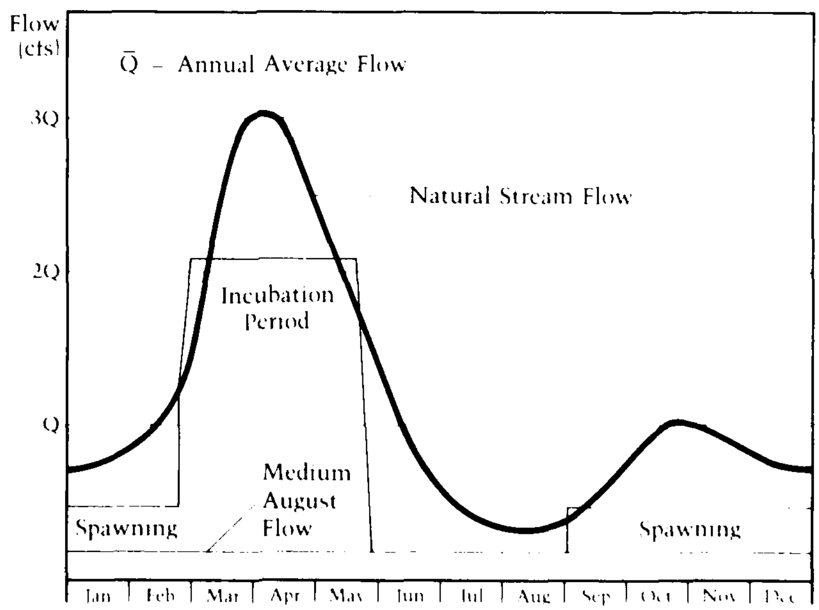


Figure 6-4: Hydrograph Showing Instream Flow Needs for Indigenous Fish

Recreation

White water and flat water recreational activities obviously depend on a certain quantity of flow. Physical characteristics of a river such as width and depth of the water, and velocity of flow must measure above some minimum threshold for canoeing, kayaking, or rafting to be possible. The minimum acceptable measure of each of these characteristics for a particular stretch will vary. For example, the minimum depth required to make a given segment suitable for expert canoeing may not make it suitable for beginners.

A second set of characteristics determine the desirability of a stream for these activities. These are specific to a given reach and may or may not be related to flow. Examples of these include the length of a reach which is uninterrupted by barriers such as dams and which is thus available for canoeing, and the scenic quality of the stream banks and surrounding environs of a given reach.

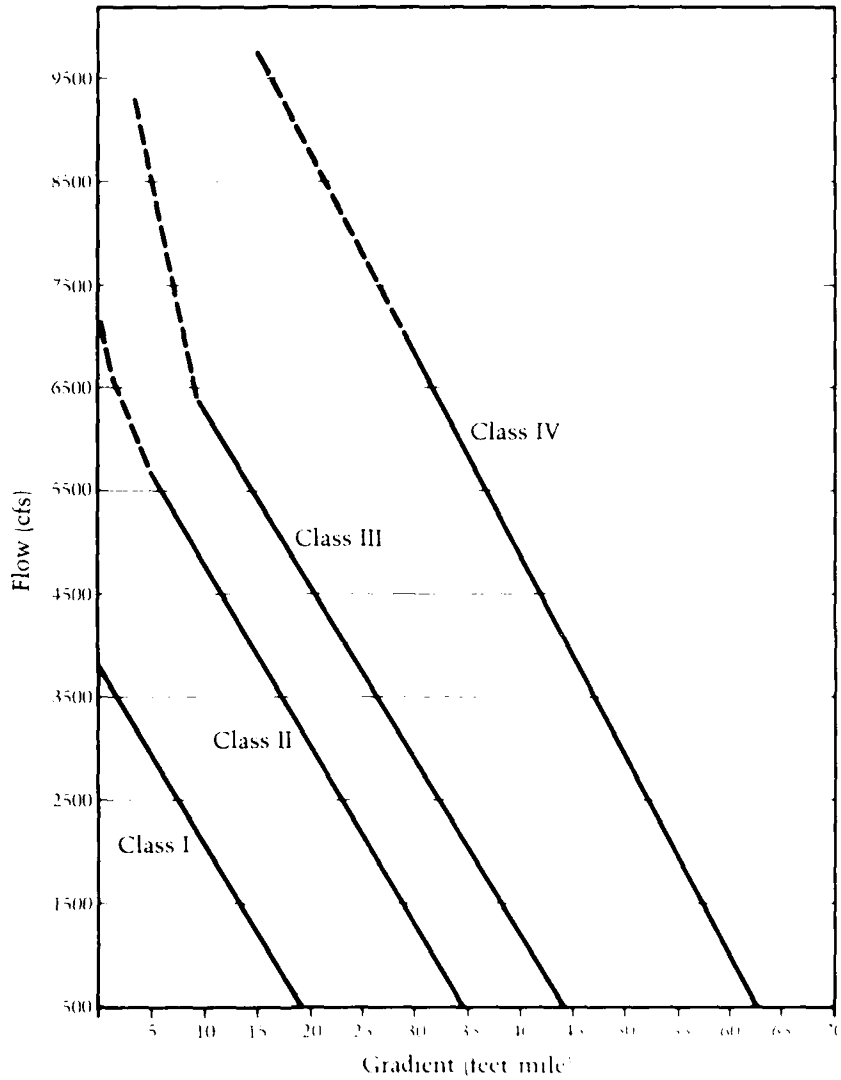
There are generally five "classes" of white water in New England, with higher classes providing a more difficult and challenging experience. Figure 6-5 shows the relationship between quantity of flow, gradient, and degree of difficulty. The exact conditions of gradient and flow that yield these classes of white water obviously vary*. A good rule of thumb is that Class I white water streams have a gradient in excess of 10 feet per mile and a flow in excess of 500 cfs.

Canoeists can negotiate waters as shallow as 3 to 6 inches, although poling is more appropriate than paddling in such shallow water. The quality of canoeing improves markedly as depths become greater than 2 feet, since at two feet, paddling without striking the bottom is possible. Widths as narrow as the length of the boat can be navigated, although a practical minimum is about 25 feet. There is no maximum width or depth which precludes canoeing, but velocities in excess of 5 feet per second impede upstream progress and mark the general lower limit of Class I white water conditions.

Demand for white water or flat water river recreation varies significantly from month to month and is primarily a function of available flow. On unregulated rivers, optimal white water is usually available only in the spring, as shown in Figure 6-6. Since stream flow decreases as the summer advances, there is seldom sufficient depth or velocity to provide challenging water during the summer months, although flat water canoeing may still be possible.

On regulated rivers, white water activity can take place during drier periods of the year on segments where flow releases from hydropower, flood control, or water supply dams provide sufficient flow. Depending

* Optimal flow conditions for specific white water segments in New England are provided in the Table in Appendix C.



Source: Arighi, S., and M. Arighi. 1974. *Wildwater Touring*. Macmillan Publishing Co. New York, N.Y.

Figure 6-5: White Water Classes as a Function of Flow and Gradient

on the extent to which release schedules coincide with periods of demand for recreation (e.g., weekends or holidays) white water activities may be possible throughout the summer and into the fall.

Scenic Quality

Any judgement regarding the minimum stream flow necessary to maintain scenic quality is highly subjective. On a free-flowing river, it is often the free-flowing quality which gives the stream its scenic character, and

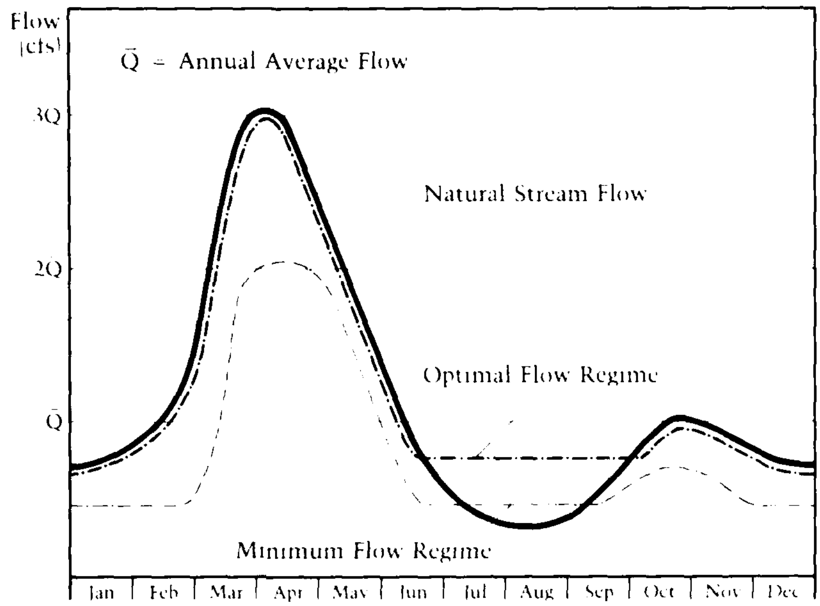


Figure 6-6: Hydrograph Showing Instream Flow Needs for River Recreation (White and Flat Water Boating)

therefore the optimal flow conditons will be those which most closely resemble natural conditions.

The Overall Impact of Hydropower Development on Instream Flow

Analysis of the instream flow needed for the maintenance of fisheries, recreation, and waste assimilation has shown that the optimal or minimum flows required to sustain each use varies considerably from season to season. Not only does the total quantity of flow required vary, but the percentage of the average seasonal flow required for each use changes from season to season.

Figure 6-7 depicts the typical flow needs for run-of-river hydropower, waste assimilation, fish, and recreation, plotted on one hydrograph for a hypothetical unregulated river in New England. Except in the case of waste assimilation, the hydrograph indicates that the greatest *quantity* of water is required for instream uses during the spring. In summer months, however, the greatest *percentage* of available flow is required to support instream uses.

Although hydropower, waste assimilation, fisheries, and recreation have overlapping flow demands, the demands need not conflict as long as one of these purposes does not require exclusive use of the water. Hydropower facilities operated in a run-of-river mode, with no diversion of flow out of the mainstem streambed, continuously provide water for waste assimilation, fisheries, and recreation, and will also maintain the scenic

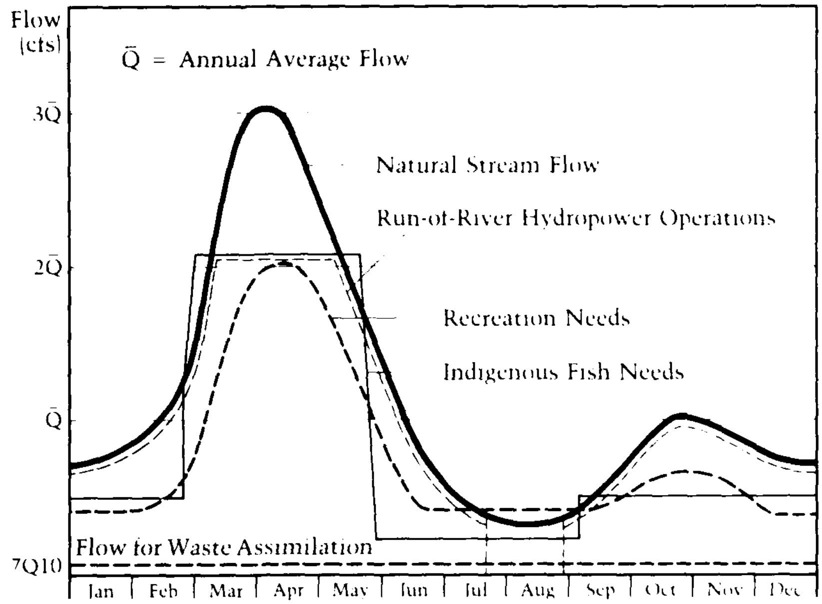


Figure 6-7: Hydrograph Showing Multiple Instream Flow Needs

character of the stream. Some uses not only do not conflict, but are dependent on each other. Fisheries, for example, require that the water quality be maintained, and this requires adequate assimilation of wastes.

The hydrographs shown in Figures 6-8 and 6-9 depict two cases in which there are very different relationships between the needs of hydropower and other uses. In the first, the run-of-river hydropower facility includes use of a penstock or open canal to gain more head by diverting water to a downstream powerhouse. Maximizing the generating capability of the plant requires the diversion of as much water as possible. The flow remaining in the by-passed streambed is shown in the shaded area. This is the flow which remains either in the spring when the turbine(s) are operating at maximum capacity and excess flows are spilled over the dam, or in that part of the summer when flows are insufficient to drive the turbines.

In the case depicted in this first hydrograph, competition for instream flows with the other uses will be severe, *if those uses require utilization of the by-passed streambed*. The only flow available will be that in the shaded area. White water recreation will be impossible in the spring and sufficient water for waste assimilation will be available only 4-5 months of the year. The needs of fisheries as defined by the Aquatic Base Flow method will be met for only a brief period when the turbines are shut down. Downstream of the powerhouse, where all the flow has been returned to the main streambed, there will be adequate flow for all uses.

The second hydrograph depicts the needs of a weekly store-and-release hydropower operation overlayed on a graph of the needs for instream

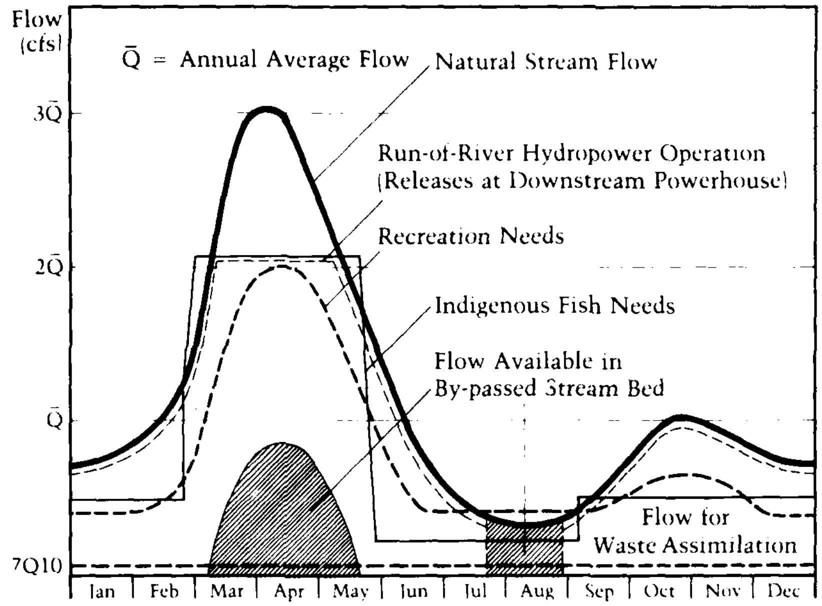


Figure 6-8: Hydrograph Showing Conflicts Between a Run-of-River Hydropower Diversion Project and Other Stream Uses

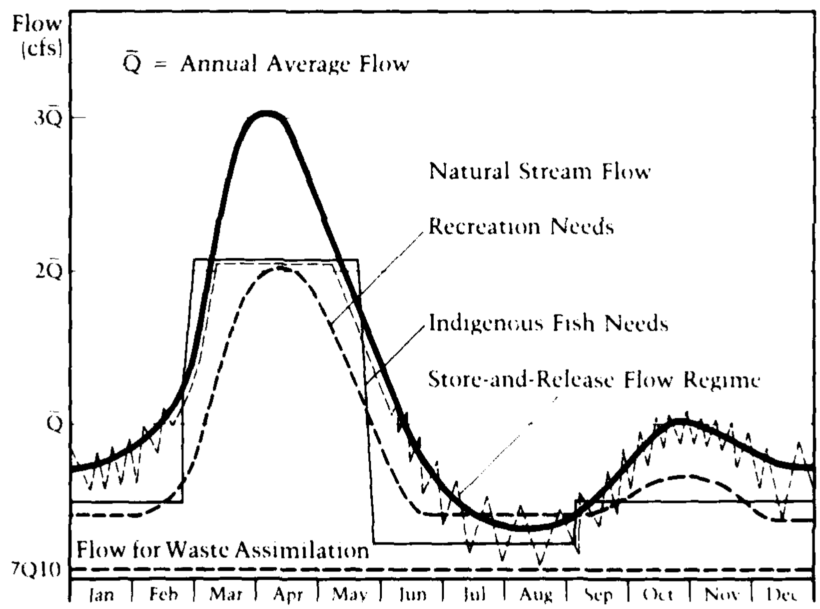


Figure 6-9: Hydrograph Showing Conflicts Between a Store-and-Release Hydropower Operation and Other Stream Uses

flow of the other uses. In this situation, competition for instream flows will be intense when the facility is storing water and the releases fall below that needed to support the other uses. Typically, this will occur on weekends, when demand for canoeing, kayaking and fishing is greatest. If, during storage periods, the release falls below the minimum threshold needed to maintain suitable conditions for fisheries, fish populations may be severely reduced.

The severity of such conflicts will obviously increase with the frequency and amount of fluctuation in flow releases from hydropower facilities. However, a daily ponding operation with limited storage capacity may not produce as severe effects as a weekly store-and-release operation which requires a much longer storage period.

Conflict Mitigation through Project Design

In many instances, it may be possible to mitigate the intensity of conflicts between hydropower development and other uses of water resources by designing and operating hydropower projects in such a way as to accomodate the needs of these competing uses. Maintenance of minimum flow releases and provision of facilities for fish passage are likely to be at issue for many sites in New England. For that reason, the feasibility of incorporating minimum flow releases and fishways into hydropower projects is discussed below.

Feasibility for Accommodating Minimum Flow Requirements

A variety of policies are being used to define the needs of different flow related uses, ranging from the 7Q10 policy recommended by the Environmental Protection Agency (EPA) and many state agencies to maintain water quality to the Aquatic Base Flow method advocated by the United States Fish and Wildlife Service (USFWS) to protect anadromous and fresh water fish. These policies may require that continuous flow releases be maintained at a powerhouse and/or dam to insure that flows downstream of the facility are adequate for protection of competing uses or resources.

To assess the effect of the policies on the economics of hydropower development, NERBC conducted a case study analysis of thirteen sites, selected from the 200+ project proposals in the region that have been submitted to FERC for preliminary permits. The sites analyzed were generally representative of the types of diversion projects being investigated throughout the region. Most were in the 500 to 5000 kw range and involved diversions of between 700 and 2000 feet.

The results of this analysis indicate that if continuous releases are required to be made at a dam where a powerhouse is located downstream at the end of a head race or penstock diversion, energy output will in most cases be substantially reduced. If consideration is given to using a small turbine at the dam to generate power from the releases, however, the reduction in energy output can be significantly lessened on some sites. On sites with large drainage basins and correspondingly larger 7Q10 or Aquatic Base Flows (ABF), in particular, the continuous releases recommended by EPA and USFWS will be larger, making power generation at the dam more feasible than it would be on smaller sites. This finding applies also to sites where there is substantial regulation of upstream flows and the 7Q10 or ABF is based on the regulated flows.

While the use of small turbines to generate power from the required releases will obviously increase capital costs, the overall effect on project feasibility was found to be less pronounced than effects on energy output. For example, using financial criteria which assumed a period of negative cash flow for private developers to be no greater than three years and an internal rate of return over the life of a project to be 15%, it was found that compliance with both the 7Q10 and an ABF requirement based on median August flow, did not substantially reduce the financial feasibility of projects which would be financially viable in the absence of any minimum flow requirements. This finding held for three different scenarios of the sale value of energy produced, i.e., 50, 70, and 90 mills kwh.

These results suggest that projects which are economically viable to begin with are likely to be able to accomodate minimum flow requirements, while the more marginal projects are going to be severely impacted by constraints on flow releases. In addition, it appears that advances made by turbine manufacturers in the last six months to a year in developing small package turbine units are likely to improve the capability to generate power from continuous releases made at a dam consistent with both the 7Q10 and ABF policies.

The USFWS cooperated in the case study analysis by assessing the thirteen sites to determine how minimum flow releases would be recommended if based on site specific application of the generic Aquatic Base Flow method. The purpose of this analysis was to determine how closely releases actually recommended for each site would correlate with generically determined release recommendations based on a regionwide median August flow of 0.5 cfs. A second purpose was to determine the likelihood that USFWS would recommend maintenance of flows higher than the median August flow during certain times of the year to support spawning and incubation (see Figure 6-4).

With respect to the first purpose, it was found to be possible to develop a more specific recommendation on only four of the sites, given the limited time available. For these four sites, however, the flows USFWS would recommend based on field observation were found to be considerably lower than that which would be required using the generic policy alone. This finding suggests that detailed analysis by applicants of hydropower projects may enable them to justify maintenance of flow releases more advantageous to hydropower generation than would be suggested by strict interpretation of the USFWS generic policy. It also emphasizes the need for fair and timely negotiations in the licensing process.

With respect to the second purpose of the USFWS analysis, it was found by the USFWS that at 87% of the sites it was unlikely that they would recommend maintenance of flows higher than the August median in the by-passed stream beds. Sixty percent of the sites studied would definitely not require releases greater than the ABF (0.5 cfsm) rate in fall, winter, or spring below their downstream powerhouses.

Taken together, the results of these case study analyses indicate that th re may be substantial flexibility for accommodating the needs of competing stream flow uses in the design and operation of hydropower projects. Irrespective of the policies applied, negotiation will be the key to resolving conflicts that may arise at any one site. The FERC will be aided in its deliberations or its role as a mediator, however, if prospective hydropower developers and advocates of competing interests alike attempt to define clearly and justify their flow needs. Furthermore, negotiations are most likely to be expedited, if competing users of stream flow strive to understand each other's perspective. While hydropower developers may believe that minimum flow requirements constrain a legitimate private sector response to the nation's critical energy situation, recreationists, fishermen, and other stream users may believe that hydropower constrains their statutorily guaranteed rights to use public resources.

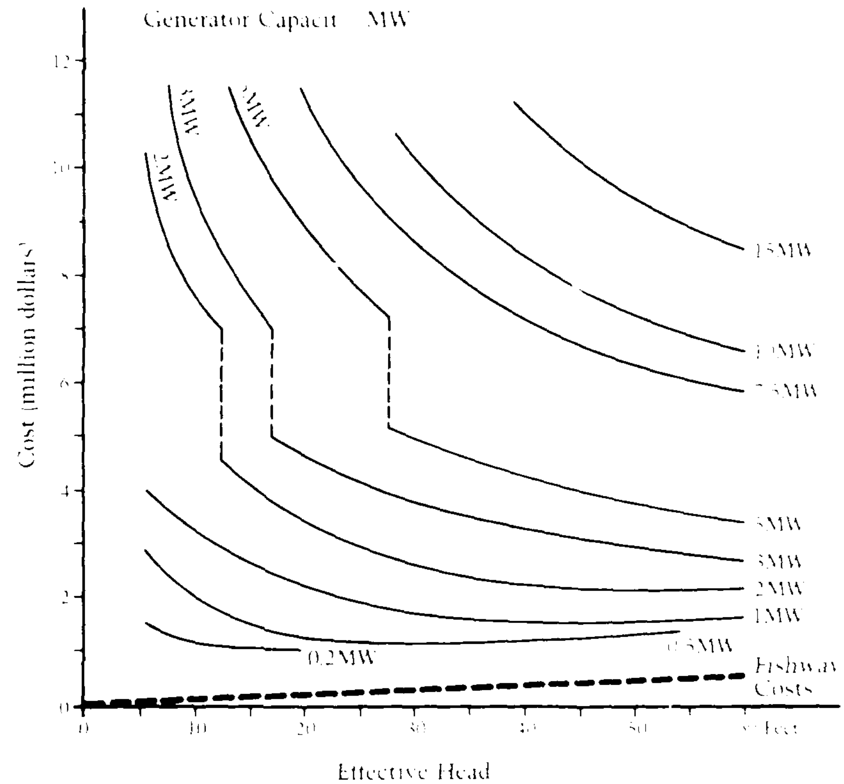
Fishways

As noted in Chapter IV, as many as one fourth of the hydropower sites likely to be developed in New England are located on existing anadromous fish runs or those currently under restoration. Some type of facilities for fish passage are likely to be required at these sites.

Fish passage costs, like many other aspects of hydroelectric projects, are highly site specific. Some generalizations can be made, however, using the graphs depicted in Figure 6-10. The graphs show the relationship between head, turbine capacity, and project cost for installation of a single power plant in or immediately adjacent to an existing dam.

Overlaid on these graphs is another curve depicting the costs of fish ladders as a function of head, assuming an average cost of $8 - 12,000 per foot of head. Such a cost range is believed to be typical for installations in New England other than those located on the mainstem of major rivers like the Connecticut or Merrimack. The costs of fish ladders on these rivers are likely to be considerably higher.

For a given head, say twenty feet, the graphs show that a fishway costing $200,000 will be about 9% of power plant costs for a one megawatt facility, about 6% of power plant costs for a two megawatt facility and about 2% of power plant costs for a five megawatt facility. Thus, for a given head, the costs of installing fish ladders will constitute an increasingly smaller portion of overall project costs as the amount of flow and the installed capacity increases. Thus, smaller projects on the lesser



Notes: Date of power plant costs is April 19[illegible]; costs are for a single unit power plant installed in the dam or as a part of the spillway; not included are costs for land and land rights, access roads and bridges, relocations, and transmission lines. *Source: EPRI, Simplified Methodology for Economic Screening of [illegible] Low-head Small Capacity Hydroelectric Sites, January [illegible]*

Figure 6-10: Fishway Costs as Compared to Capital Costs of Power Plants Installed at Existing Dams

tributaries are more likely to be rendered less economically feasible if fish ladders are required than are larger projects which can take advantage of greater quantities of flow to generate more power at a higher installed capacity. To the extent that this graph provides an accurate depiction of the situation at low head dams in New England, it suggests that fish passage requirements may make smaller projects economically infeasible. However, there is limited information to support such a contention, since most projects are currently only in the preliminary feasibility stage.

Trap and truck operations at smaller dams may also be feasible although such operations will require an annual expenditure rather than a one time capital cost. Generally, trap and truck operations are used as an interim measure only.

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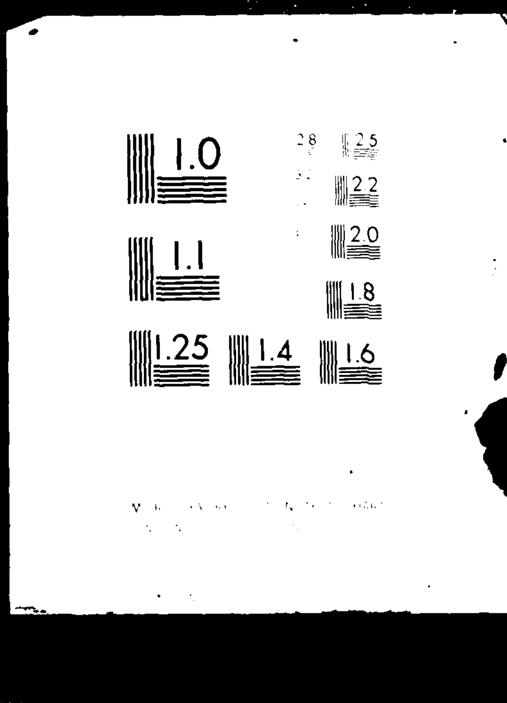

Fish passage requirements are not always imposed at the time a project is begun. License conditions may require that passage facilities be provided at a future date when specific levels of returning anadromous fish have been recorded at the base of the dam. Alternatively, fish passage requirements may have to be met within a specified time period following the removal of the next barrier immediately downstream. The Merrimack Fish Passage Action Plan, for example, is based upon this latter approach. Therefore, fish passage investments may not have to be made until a considerable amount of time has elapsed after the generating facility has come on-line. By that time the project may be in a better position to support the costs of the fishway since it will have been generating revenues for some time. However, to minimize these future costs, some costs may have to be incurred at the time of initial project development, such as providing foundation footings for future installation of fish passage facilities. Downstream passage facilities may be requested immediately if upstream trucking is providing natural reproduction above the hydropower development site.

The degree to which installation of fishways at existing dam hydropower projects will affect economic feasibility is in large part dependent on how one defines economic feasibility. If the costs of fishway construction are considered be to on a co-equal basis with the costs of dam repairs, turbines, and generators, the sum total of all of these costs will determine whether a developer considers a project economically feasible. However, if the costs of fishway construction are not included in initial analyses of project costs, but are considered additional costs imposed by the regulatory system, they are likely to be singled out as solely responsible for rendering projects infeasible. This argument is heard often in conjunction with situations where existing dams already pose a barrier to fish migration.

Furthermore, private entrepreneurs who are seeking a fair rate of return on their investment may find the costs of fishways cutting substantially into their profit margin, while publicly regulated utilities may be able to pass the costs of fishways and other mitigation measures onto the rate paying consumer. These varying interpretations of course reflect philosophical differences which have no resolution. The fact that they continue to exist, however, suggests that developers would be wise to investigate possible fish passage needs early on in the feasibility study stages of project development.

In the case of new or breached dams located on rivers or streams significant for anadromous fishery, the burden of fish passage costs unquestionably should lie with the project applicant. In these situations, construction or reconstruction of dams will create barriers to fish migration that do not currently exist.

Avoiding Conflict

Although the demand for dam sites in New England is currently very strong, the great number of existing dams at which hydropower generation is feasible provides an opportunity for interested developers to locate sites where conflicts with other water uses are likely to be minimal. In addition, the design and operation of hydro facilities at existing dams which minimize the need for stream flow diversion or regulation (i.e. facilities operated in the run-of-river mode with the powerhouse installed at or near the base of the dam) will reduce the likelihood of conflict even on streams which are intensively used for other instream uses.

The maps provided by NERBC in conjunction with this report are intended to facilitate the process of identifying sites with the least potential for competition over instream flow. Significant fisheries, recreation areas, and scenic reaches have been indicated in order to make it possible to identify stream segments which are valuable for uses other than hydropower. The identification of these segments is based either on established agency priorities for resource management (e.g. anadromous fisheries) or on the consensus of various constituency groups which have a strong interest in the use and protection of certain water-related resources (e.g. inland cold water fisheries, recreation areas, or scenic reaches).

The development of hydropower facilities on these segments, if not compatible with existing flow regimes or stream uses, is likely to encounter substantial opposition, resulting in lengthy licensing delays and perhaps costly litigation. Development on other segments is likely to cause less opposition, although it is impossible to determine on an *a priori* basis that any one site will be absolutely free from conflict or opposition.

Prospective developers can substantially reduce conflict and delay if they utilize these maps to select sites at which minimal conflict is likely. Consultation with the relevant state and federal regulatory agencies also can help to reduce conflict and delay, particularly if such consultation is undertaken in advance of detailed project design and preparation of license applications. The preliminary permit process administered by the FERC provides a productive mechanism for such consultation, as potential problems can be identified by agencies or other reviewers early in the feasibility stage of project development. This can allow the tailoring of project design and operation to accommodate specific instream flow demands or needs of other uses the value of which may be equally as important as the benefits of hydropower.

Finally, it has become clear during the course of the study conducted by NERBC that opposition to the construction of new dams at previously undeveloped sites is likely to be substantial. In many cases development of hydropower at such sites would conflict with already established uses of major significance to the region (see Chapter V). In a region where there already exist in excess of 10,000 dams, the number of remaining free-flowing river segments is limited. Many of these sites are highly valued for their fisheries, and for their recreational, scenic, and other assets. If these assets were lost as a result of the construction of new impoundments, it would not be possible to compensate for their loss. Thus, while the merits of hydropower development at new dams considered in relation to the merits of maintaining and protecting competing uses will obviously have to be evaluated on a case by case basis, developers should recognize that proposals for construction of entirely new facilities will not easily be implemented.

Coordinated Basin Development

The reference to a comprehensive plan in Section 10A of the Federal Power Act suggests a final approach to avoiding conflict. The development of comprehensive plans through cooperative arrangements between development interests and appropriate state and federal agencies would provide a basis for coordinating the development of hydropower facilities with the protection or enhancement of other uses of rivers.

There are certain advantages to a basinwide approach that are not available in a site by site development process. These include:

- the potential to optimize power output by augmenting stream flow with upstream storage and coordinating flow releases to accommodate the load and operational requirements of facilities throughout the system;
- the ability to limit mainstem operations to run-of-river facilities, and to provide storage only in upstream tributaries;
- the flexibility to negotiate compromises in favor of hydropower at certain sites in return for accommodating different uses at other locations; and
- the capability to enhance a variety of objectives concerning river use such as using upstream storage to lengthen the season during which flow is sufficient for recreation as well as for hydropower generation.

Basinwide planning has many advantages, but making it work is a difficult challenge. It requires the cooperation of private and public sectors, and the financial and other resources necessary to support the planning process, to implement the plan, and to assure continued compliance with the plan.

These are surmountable obstacles and there are several examples in New England where people and communities have been willing to meet the challenge. The West River in Vermont, Salmon Falls in New Hampshire, and the St. John in Maine are three areas where basinwide planning has been instituted or is being seriously investigated. Substantial precedent has also been set by some utilities and the forest products industry for coordinated regulation of river flow throughout entire basins, such as the Androscoggin in New Hampshire and Maine.

Appendix A: Existing and Breached Dam Sites

All existing and breached dam sites shown on the maps accompanying this report are listed in the following sections, arranged by basin and printed in rank order of their estimated cost per kilowatt hour of energy generated. These sites were screened from an inventory of more than 10,000 dam sites, published in the January 1980 report, *Potential for Hydropower Development at Existing Dams in New England*. All have an estimated energy cost less than 125 mills per kilowatt hour. Capacities shown are for a plant factor of 70%. The methodology employed is fully documented in the January 1980 report available from the National Technical Information Service in Washington D.C. (see ordering details below). Basic assumptions used in the computer model to analyze the sites are summarized below.

Basic Hydrologic and Engineering Assumptions

- Hydrology is characterized by two features: mean flow and annual flow-duration curve.
- Mean flow at any dam is proportional to drainage area contributing to that dam.
- All sites have effective head equal to 95 percent of gross dam height.
- For development at a 70% plant factor, 70% of annual flow is considered available for power generation.
- All sites have combined turbine-generator efficiency equal to 88 percent.
- All projects are independent; no project influences the hydrology of any other project.
- During periods when flow is substantially below design flow, turbine-generator efficiency is maintained.

Basic Economic Assumptions

- Construction cost is the sum of dam rehabilitation expenditures, power station costs, and a contingency allowance.
- The cost of dam rehabilitation per foot of height depends on tne dam type (earthen or concrete) and height.
- Power station costs depend on the magnitude of the requirement (install package unit only, refurbish existing station, or total redevelopment) and on capacity.
- Connection to the grid entails no cost to the developer.
- Rehabilitation of the conveyance is included in the contingency allowance.
- No costs are associated with the penstock.
- No costs are associated with compensation for loss of competing uses for the land used by the reservoir.
- The interest rate of 15% is constant during construction and over the life of the project.

- Engineering and design costs range from 5 to 7.2 percent of total construction costs. This category of cost includes engineering design, surveys, and preparation of plans and specifications.
- Supervision and administration costs depend on total construction cost. They are derived from a curve that ranges from 6.5 to 8.6 percent, and they include inspection, supervision, and general overhead.
- The construction time is 1 to 4 years, depending on the total construction cost, with a separate calculation for interest costs incurred during construction if the construction period is greater than two years.
- Calculation of total investment includes all dam costs, powerhouse expenditures, contingency allowance, supervision and administration costs, engineering and design costs, and interest during construction.
- Annual costs of dam operation include the annual expenditures for interest and principal, operation and maintenance, major item replacement, taxes, and insurance.
- Operation and maintenance costs range from $1.80/kw to $3/kw, depending on the size of the installed capacity.
- No downstream costs or benefits are included in the analysis.

Availability of "Potential for Hydropower Development at Existing Dams in New England"

Due to continued demand for the eight volume series published by NERBC in January 1980, ordering information is provided below. NERBC will be terminated on October 1, 1981. In the interim period and thereafter, copies of the eight volume set can be obtained from the National Technical Information Service in Washington D.C.

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		NTIS Accession No.	Paper Copy	Micro-Fiche
Volume I	Physical & Econ. Findings & Methodology	PB80-169121	$15.50	$3.50
Volume II	User's Manual**	PB80-169139	$12.50	$3.50
Volume III	Connecticut	PB80-169147	$17.00	$3.50
Volume IV	Maine	PB81-193310	$18.50	$3.50
Volume V	Massachusetts	PB81-194243	$23.00	$3.50
Volume VI	New Hampshire	PB81-193294	$29.00	$3.50
Volume VII	Rhode Island	PB81-193302	$11.00	$3.50
Volume VIII	Vermont	PB80-169154	$15.50	$3.50

* Reproduction of state volumes includes the maps.
** Generally of interest to computer technicians only.

Existing and Breached Dams

Connecticut

70% Plant Factor, 15% Interest Rate

Thames River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
CT 1227	PUTNAM	ROSENFLD DMPU1	16.	601.	3607.	21.0
CT 579	PLAINFIELD	CTNONAME 41	20.	195.	1172.	23.5
CT 1468	WINDHAM	AMER TH DM W13	20.	587.	3521.	47.7
CT 1469	WINDHAM	AMER TH DM W14	15.	439.	2632.	54.0
CT 1465	WINDHAM	AMER THR DM W9	10.	293.	1759.	65.8
CT 678	PUTNAM	CARGILL FALLS	28.	404.	2424.	76.6
CT 539	LISB GRISW	CTNONAME 36	13.	1098.	6591.	83.8
CT 1186	NORWICH	FALLS MILDMN13	25.	317.	1903.	92.3
CT 182	THOMPSON	CTNONAME TEN	21.	303.	1818.	95.7
CT 513	BROOK KILL	CTNONAME 26	14.	699.	4193.	99.3
CT 437	GRISWOLD	ASHLAND POND	18.	146.	876.	99.5
CT 1467	WINDHAM	AMER TH DM W12	20.	588.	3526.	105.9
CT 179	PUTNAM	CTNONAME NINE	14.	526.	3156.	110.7
CT 171	KLNGLY POM	ROGERS CORP DA	10.	490.	2941.	114.0
CT 198	MANSF WIND	WILLIMANTIC RE	20.	421.	2527.	122.2

Connecticut River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL/KWH
CT 370	NEW HRTFRD	NEPAUG RES 370	113.	464.	2857.	8.7
CT 376	BARKHAMSTD	BARKHAMSTED RS	135.	921.	5670.	8.7
CT 541	HARTLAND	HOGBACK DAM	104.	1717.	10566.	10.3
CT 50749	BURLAVON	COLLINS CO B3	18.	842.	5184.	20.0
CT 674	CANTON	COLLINS CO DAM	20.	933.	5744.	38.6
CT 380	AVONBURLNG	COLINS CO LW D	20.	936.	5760.	38.6
CT 897	FARMINGTON	FARMINGTON F12	5.	291.	1792.	64.4
CT 371	NEW HRTFRD	COMPENSATING R	45.	358.	2203.	81.9
CT 621	VERNON	PAPER MILL PON	74.	165.	1012.	84.8
CT 20835	EGRNBYSIMS	TARIFVL DM E 1	20.	1485.	9136.	87.8
CT 529	ENFIELD	CTNONAME 31	25.	215.	1324.	123.5

Note: Any 5-digit dam number beginning with a "2" is a breached dam (e.g., CT 20835)

Housatonic River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL/KWH
CT	26	DERBYSHELT	LK HOUSATONIC	35.	6611.	41868.	17.9
CT	89	SEYMOUR	KINNEYTOWN DAM	30.	1080.	6840.	19.1
CT	549	KENT	SPOONER DAM	17.	1593.	10091.	29.0
CT	399	SEYMOUR	RIMMON POND	30.	1080.	6840.	38.7
CT	229	NW MILFORD	CTNONAME FORTN	12.	1613.	10214.	65.9
CT	665	WARRENLITC	SHEPAUG RES	62.	283.	1791.	72.9
CT	1019	LITCHFLD	BANTA PROJ L1	50.	241.	1528.	77.5

Western Connecticut Coastal Rivers

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL/KWH
CT	108	WESTON	S P SENIOR DAM	110.	495.	2969.	8.9
CT	20	EASTON	EASTON RESVOR	120.	200.	1198.	10.9

Central Connecticut Coastal Rivers

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL/KWH
CT	629	WALLINGFRD	CTNONAME 48	10.	128.	771.	46.3
CT	400	KILLINGWRT	HAMMONASSET DM	60.	160.	959.	117.6

No dams in the **Eastern Connecticut Coastal Rivers** or the **Pawcatuck River Basin** pass

Maine

70% Plant Factor, 15% Interest Rate

St. John River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL/KWH
ME	2245	CARIBOU	LTL MADAWASK D	32.	960.	5920.	42.1
ME	22481	HOULTON	CARYS MILLS	24.	475.	2930.	66.2
ME	2233	ASHLAND	SHERIDAN DAM	7.	1030.	6349.	86.4
ME	2319	T10R3 WELS	WHITNEY BK DAM	27.	292.	1798.	95.5

St. Croix River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL/KWH
ME	21934	CALAIS	CALAIS UNION D	11.	1940.	11966.	92.5
ME	1932	VANCEBORO	VANCEBORO DAM	13.	679.	4185.	97.1
ME	21941	CALAIS	MILLTOWN DAM	12.	2117.	13054.	102.1
ME	21942	CALAIS	MURCHIE DAM	10.	1716.	10582.	109.0
ME	1916	GRND LK ST	W GRAND LK OUT	14.	403.	2486.	120.8

Penobscot River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
ME	704	OLD TOWN	BANGOR HYDRO	5.	4564.	28142.	18.4
ME	700	BREW	CITY OF BANGOR	17.	15830.	97621.	26.5
ME	869	SEBOOMK TW	SEBOOMOOK L DM	32.	2112.	13024.	30.0
ME	847	T06R08WELS	GRAND LAKE DAM	25.	1410.	8695.	34.9
ME	2991	T6R11	TELOS LK OUTLT	42.	1361.	8392.	35.4
ME	1888	MILO	MILO EL LGHT P	22.	1143.	6856.	39.5
ME	885	PTTSTN A G	CANADA LK FL D	26.	590.	3636.	56.7
ME	775	DVR FXCRFT	DVR FXCFT TWO	16.	788.	4731.	94.6
ME	791	SEBEC	BNGR HYDRO SLD	14.	727.	4363.	97.4
ME	1775	DOVRFOXCRF	DVR FXCT WT DT	12.	591.	3548.	105.1
ME	790	MILO	TWN MILO MILOD	10.	570.	3419.	106.6
ME	776	GUILFORD	GUILFORD IND D	12.	425.	2550.	121.0

Kennebec River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
ME	582	DENNIS PLT	CROCKER PD DAM	229.	69.	424.	15.3
ME	460	BURNHAM	BURNHAM HYDRO	27.	1980.	12208.	18.4
ME	577	TIRI	BRASSUA LK DAM	31.	2701.	16654.	27.8
ME	415	GARDINER	AMRCNTSSUEMILL	37.	977.	6024.	41.7
ME	22525	ANSON	CLEVELAND RIPS	29.	1624.	9744.	41.8
ME	21525	ANSON	NANSON DAM	35.	1960.	11760.	42.3
ME	451	OAKLAND	CTRL ME PWRI	25.	525.	3237.	43.7
ME	20048	BENTNFAIRF	KENNEBEC MILL	10.	5112.	31524.	45.8
ME	23525	NEWPORTLND	E NEWPORTLNDDM	26.	1252.	7513.	46.6
ME	414	GARDINER	YRKTWNEPPRMILL	18.	475.	2930.	50.5
ME	464	HARTLAND	GRTMOOSELK DAM	21.	592.	3652.	56.5
ME	410	BIG SQUAW	MSHD L E OUTLT	14.	2083.	12846.	58.6
ME	552	T3R4BKPWKR	FLAGSTFLKOTDAM	63.	340.	2098.	66.1
ME	534	NEWPORTLND	GILMAN ST DAM	26.	488.	2927.	66.4
ME	20052	SKOWHEGAN	ANDERSON MLS D	25.	11850.	73075.	66.9
ME	462	PITTSFIELD	TOWNOFPITTSFLD	15.	576.	3552.	103.3
ME	20063	BENTON	N BENTNFLLS DM	15.	1586.	9779.	110.5
ME	561	EUSTIS	N BR DEAD R DM	16.	453.	2794.	114.3
ME	572	FRKSEMOXIE	MOXIE POND DAM	21.	224.	1383.	118.4
ME	20064	CLINTON	CLINTON	8.	815.	5026.	119.8

Note: Any 5-digit dam number beginning with a "2" is a breached dam (e.g., CT 20835)

Androscoggin River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
ME 236	JAY	OTIS DAM	24.	8366.	50198.	25.2
ME 110	JAY	RILEY INTER PA	25.	8540.	51240.	25.5
ME 197	TOWNSHIP C	M DM UN WTR PR	47.	3349.	20095.	27.3
ME 121	AUBURN	AUBURN DAM	38.	1862.	11172.	32.2
ME 120	AUBURN	BARKER MILL UP	36.	1688.	10130.	34.5
ME 198	RCHRDTWN T	UNION WTR P CO	21.	1191.	7144.	38.7
ME 199	STSTN TWP	CNTL ME PWR CO	32.	654.	3924.	38.8
ME 191	LINCOLN PT	AZISCOHOS DAM	55.	1655.	9933.	41.8
ME 119	AUBURN	BARKER MILL LO	51.	2499.	14994.	42.9
ME 20029	BYRON	SWIFT RV DAM D	35.	588.	3528.	62.6
ME 200	STSTN TWP	CNTL ME PWR CO	25.	511.	3066.	64.3
ME 20033	CARTHAGE	BERRY MLLS WR	30.	512.	3074.	73.1
ME 204	STSTN TWP	CNTL ME PWR CO	24.	376.	2258.	80.4
ME 20178	CARTHAGE	WEBB LAKE DAM	24.	286.	1714.	99.8
ME 123	MINOT	ROGERS FIBER C	11.	477.	2864.	114.7
ME 21007	MECHANIC F	MECHANIC FALLS	12.	422.	2530.	121.4

Saco River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
ME 1609	FRYEBURG	SWAN FALLS DAM	10.c	774.	4747.	41.6
ME 1616	LIMERWTRBY	LEDGEMERE DAM	34.c	775.	4755.	47.8
ME 21603	BDFD SACO	SPRNG BRDBY DM	14.c	3570.	21896.	84.5
ME 1626	PORTR PARF	OSSIPEE DAM	13.c	819.	5023.	91.3
ME 1627	PORTR PARF	OSSIPEE DAM2	7.c	441.	2705.	116.3

Eastern Maine Coastal Rivers

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL/KWH
ME 4401	ELLSWORTH	GRAHAM LAKE	23.c	1455.	9252.	23.4
ME 3418	MACHIAS	MACHIAS R D 4	28.c	1764.	11214.	35.7
ME 23900	COLUMBIA	SACO FALLS DAM	55.c	539.	3426.	71.5
ME 3416	MACHIAS	MACHIAS R D 2	20.c	1260.	8010.	86.0
ME 3415	MACHIAS	MACHIAS R LD 1	20.c	1274.	8099.	123.3

Southern Maine Coastal Rivers

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL/KWH
ME 3601	KENNEBUNK	KNBNK L + P L DM	13.c	208.	1247.	79.3

Piscataqua River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
ME 1002	SO BERWICK	RT FOUR DM	24.0	786.	4717.	20.5
ME 1018	SO BERWICK	LEIGHS ML PD	28.0	313.	1878.	22.0

Central Maine Coastal Rivers

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
ME 4108	UNION	CRAWFRD P OUT2	40.	156.	936.	24.4
ME 5051	CAMDEN	KNOWLTONST DAM	22.	71.	429.	30.1
ME 4100	UNION	SENEBEC PD OUT	35.	528.	3167.	62.8
ME 3800	BELFAST HM	JOHNSONS AUTO	30.	164.	983.	113.1
ME 5063	BRISTOL	BRISTOL MILLS	35.	150.	901.	123.4

Presumpscot and Casco Bay Drainage Area

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
ME 51308	STANDISH	STANDISH DAM	40.	2272.	13634.	30.1
ME 21377	BRIDGTON	STEVNS BK DM 9	50.	351.	2106.	87.7
ME 1301	WESTBROOK	WESTBRK DM 1	6.	423.	2536.	121.3

Massachusetts

70% Plant Factor, 15% Interest Rate

Merrimack River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
MA 4955	SOUTHBORO	SUDBURY RESERV	0.	309.	1906.	6.8
MA 4302	CLINTON	WACHUSETT RES	114.	1477.	9111.	9.7
MA 5103	LOWELL	SWAMP LOCK DAM	16.	7680.	47360.	23.3
MA 5106	LOWELL	NO.CANAL LOC D	30.	14400.	88800.	25.0
MA 5104	LOWELL	OLD GUARD LOCK	22.	10560.	65120.	26.8
MA 3955	FITCHBURG	MACTAGGARTS PD	98.	176.	1088.	60.8
MA 4303	CLINTON	LANCASTER ML P	25.	327.	2016.	62.3
MA 4957	FRAMINGHAM	RESERVOIR ONE	22.	201.	1237.	92.8
MA 4615	HUDSON	MAIN ST DAM	12.	141.	870.	99.0
MA 4964	FRAMINGHAM	SAXONVIL DM PD	25.	246.	1517.	110.2
MA 4551	SHIR HARVA	FT DEVONS DAM	15.	459.	2830.	114.2
MA 4958	FRAMINGHAM	RESERVOIR TWO	26.	144.	885.	124.3

Note: Any 5-digit dam number beginning with a "2" is a breached dam (e.g., CT 20835)

Massachusetts Coastal Rivers

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
MA 5711	NEWTONWELS	CHS NEWTON UPF	10.	253.	1561.	39.6
MA 5701	NEWT NEEDM	NEWTON UPR FLS	15.	380.	2342.	56.2
MA 5004	MEDWAYFRAN	MEDWAY DAM PD	14.	109.	673.	118.5
MA 5706	WATERTOWN	WATERTOWN DAM	13.	415.	2559.	119.8

Thames River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
MA 3568	STURBRIDGE	STURBRG VIL PD	10.	95.	571.7	50.4
MA 3862	DUDLEY	QUINEBAUG RV P	17.	336.	2016.	61.4
MA 3557	SOUTHBRIDG	AMERICAN OPTIC	13.	199.	1197.	81.7
MA 3556	SOUTHBRIDG	R HARRINGTN PD	13.	172.	1034.	89.4
MA 3873	WEBSTER	PHILS DAM	12.	131.	786.	107.0
MA 3866	WEBSTER	NO WEBST VILLA	10.	110.	663.	120.6

Connecticut River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
MA 1705	SO HAMPTON	TIGHE CARM RES	125.	210.	1277.	10.5
MA 1700	RUSEL MONT	CRESCENT MILLS	25.	1234.	7485.	19.8
MA 3162	WARE	WARE IND DAM	23.	461.	2804.	21.1
MA 3404	BARRE	S BARRE DAM	20.	142.	861.	24.6
MA 22462	MNTGERVNG	MILLER FAL TWO	32.	1494.	9087.	31.0
MA 2203	HADLEY	LAKE WARNER	15.	54.	328.	33.2
MA 2456	MNTG ERVNG	BOOK BINDERY P	20.	936.	5694.	39.0
MA 1856	CONWAY	CONWAY POWER DM	94.	367.	2224.	47.7
MA 3163	WARE	WARE CENTER DM	15.	301.	1829.	64.1
MA 2308	CHICOPEE	CHICOPEE FALLS	18.	1542.	9382.	70.2
MA 1802	COLRAIN	KENDALL CO NO1	15.	193.	1174.	82.3
MA 2754	ATHOL	LAKE ROHUNTA	72.	173.	1051.	82.4
MA 1758	WESTFIELD	STEVENS P DAM	16.	190.	1150.	83.3
MA 1750	RUSSELL	THE GORGE	45.	351.	2129.	84.4
MA 22608	LDLW WLBHM	COLLINS DAM	12.	981.	5966.	89.2
MA 21805	COLRAIN	MASSANETT	28.	370.	2242.	95.4
MA 3412	BARRE	FILTRATION DAM	20.	132.	803.	105.0
MA 22053	W SPR AGA	W SPRINGFD 2	14.	1063.	6446.	107.8
MA 1114	SANDSFIELD	CLAM LAKE	88.	116.	707.	109.8
MA 2457	MNTNGERVNG	MILLER FAL ONE	10.	468.	2847.	114.8

Houstonic River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
MA	500	GT BARRING	RISINGDALE PD	22.	801.	4928.	33.5
MA	456	STOCKBRIDG	GLENDALE	21.	710.	4368.	36.1
MA	707	DALTON	DALTON DAM SIX	20.	143.	880	98.3
MA	708	DALTON	CENTER POND	19.	133.	821.	103.1
MA	755	LEE	COLUMBIA MILL	15.	419.	2580.	119.4

Hudson River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
MA	909	CLARKSBURG	HEWAT DAM	18.	98.	611.	26.4
MA	906	NO ADAMS	RENFREW	13.	71.	441.	29.3

Narragansett Bay Drainage Area

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
MA	5853	NORTON	BARROWSVLL OD	20.	73.	437.	30.0

Blackstone River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
MA	4759	BLACKSTONE	TUPPER DAM	33.	1120.	7063.	38.2
MA	4412	GRAFTON	FISHERVILLE PD	20.	346.	2181.	57.6
MA	24424	NORTHBRIGE	BLACKSTONE DAM	15.	271.	1710.	121.0
MA	4766	BLACKSTONE	BLACKSTONE DAM	8.	373.	2355.	123.5

New Hampshire

70% Plant Factor, 15% Interest Rate

Saco River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
NH	2008	JACKSON	WILDCAT BROOK	112.	391.	2393.	6.6
NH	1281	EFFINGHAM	CENTRL ME POWR	15.	857.	5251.	40.2
NH	943	CONWAY	NONAME BRK 2	10.	605.	3704.	102.6

Note: Any 5-digit dam number beginning with a "2" is a breached dam (e.g., CT 20835)

Androscoggin River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
NH 431	BERLIN	SAWMILL DAM	17.	3261.	19564.	21.6
NH 1351	ERROL	ERROL DAM	15.	2299.	13797.	57.4
NH 21205	DUMMER	ANDROSCOGIN RV	15.	2625.	15750.	115.8

Merrimack River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
NH 4364	WILTON	SOUHEGAN R 1	20.	233.	1474.	21.7
NH 550	BRISTOL	NEWFOUND RV 2	16.	230.	1395.	22.7
NH 1455	FRANKLIN	WINNIPESAUKE 3	25.	1306.	7719.	26.7
NH 3218	PEMBROKE	SUNCOOK RIV 3	37.	1119.	7086.	27.0
NH 156	ANTRIM	STEELE POND	84.	605.	3830.	27.1
NH 1580	GOFFSTOWN	PIS R GL F	59.	1345.	8520.	27.3
NH 3217	PEMBROKE	SUNCOOK RIVER	33.	998.	6320.	28.7
NH 896	CONCORD	CONTOOCOOK RIV	17.	1561.	9884.	29.3
NH 2321	LONDONDERY	BEAVER RANKIN	13.	59.	373.	30.8
NH 2827	NASHUA	MINES FALLLLS	35.	1730.	10959.	31.5
NH 1469	FRANKLIN	GILES POND	92.	345.	2093.	38.6
NH 1460	FRANKLIN	WINNIPESAUKE 8	18.	966.	5708.	39.7
NH 2581	MANCHESTER	PISCATAQUOG 1	22.	565.	3578.	40.7
NH 1458	FRANKLIN	WINNIPESAUKE 6	17.	899.	5315.	40.9
NH 1454	FRANKLIN	WINNIPESAUKE 2	17.	888.	5249.	41.1
NH 1453	FRANKLIN	WINNIPESAUKE 1	17.	888.	5249.	41.1
NH 1457	FRANKLIN	WINNIPESAUKE 5	17.	888.	5249.	41.1
NH 894	CONCORD	CONTOOCOOK RIV	8.	734.	4651.	41.3
NH 1456	FRANKLIN	WINNIPESAUKE 4	16.	836.	4940.	42.1
NH 1873	HILLSBORO	CONTOOCOOK R 2	21.	902.	5714.	42.6
NH 895	CONCORD	CONTOOCOOK RIV	7.	646.	4091.	43.4
NH 554	BRISTOL	NEWFOUND RV 6	9.	124.	753.	46.2
NH 1850	HENNIKER	CONTOOCOOK RIV	12.	547.	3466.	46.5
NH 3216	PEMBROKE	SUNCOOK RIV 1	18.	544.	3447.	46.6
NH 1957	HOPKINTON	CONTOCOK R TWO	10.	466.	2949.	49.9
NH 893	CONCORD	SEWALS FALLS	12.	3216.	20365.	50.8
NH 2130	LACONIA	AVERY DAM	11.	488.	2881.	52.4
NH 401	BENNINGTON	CONTOOCOOK 4	15.	346.	2189.	57.3
NH 20560	BRISTOL	NEWFOUND RV 11	30.	423.	2566.	59.6
NH 402	BENNINGTON	MONADNOCK MILL	13.	300.	1897.	61.7
NH 22257	LINCOLN	E BR PEMIGE 1	28.	460.	2790.	62.3
NH 3593	SALEM	SPIC R WHEELRS	80.	223.	1411.	63.2
NH 398	BENNINGTON	CONTOOCOOK R 1	12.	265.	1679.	65.8
NH 2986	N IPSWICH	WALERLOOM POND	68.	188.	1194.	73.9
NH 2828	NASHUA	JACKSON ML	19.	939.	5949.	84.5
NH 3346	PITTSFIELD	SUNCOOK R 2	21.	330.	2091.	84.7

Houstonic River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
MA 500	GT BARRING	RISINGDALE PD	22.	801.	4928.	33.5
MA 456	STOCKBRIDG	GLENDALE	21.	710.	4368.	36.1
MA 707	DALTON	DALTON DAM SIX	20.	143.	880.	98.3
MA 708	DALTON	CENTER POND	19.	133.	821.	103.1
MA 755	LEE	COLUMBIA MILL	15.	419.	2580.	119.4

Hudson River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
MA 909	CLARKSBURG	HEWAT DAM	18.	98.	611.	26.4
MA 906	NO ADAMS	RENFREW	13.	71.	441.	29.3

Narragansett Bay Drainage Area

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
MA 5853	NORTON	BARROWSVLL OD	20.	73.	437.	30.0

Blackstone River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
MA 4759	BLACKSTONE	TUPPER DAM	33.	1120.	7063.	38.2
MA 4412	GRAFTON	FISHERVILLE PD	20.	346.	2181.	57.6
MA 24424	NORTHBRIGE	BLACKSTONE DAM	15.	271.	1710.	121.0
MA 4766	BLACKSTONE	BLACKSTONE DAM	8.	373.	2355.	123.5

New Hampshire

70% Plant Factor, 15% Interest Rate

Saco River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
NH 2008	JACKSON	WILDCAT BROOK	112.	391.	2393.	6.6
NH 1281	EFFINGHAM	CENTRL ME POWR	15.	857.	5251.	40.2
NH 943	CONWAY	NONAME BRK 2	10.	605.	3704.	102.6

Note: Any 5-digit dam number beginning with a "2" is a breached dam (e.g., CT 20835)

Merrimack River Basin (cont.)

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
NH 3347	PITTSFIELD	SUNCK R THREE	21.	302.	1915.	90.8
NH 599	CAMPTON	MAD RIVER ONE	36.	311.	1887.	92.7
NH 137	ANDOVER	BLACKWATER RV	10.	139.	880.	97.4
NH 1848	HENNIKER	CONTOCOK VALY	13.	583.	3695.	100.6
NH 3236	PETERBORO	CONTOOCOOK R 2	21.	173.	1098.	102.5
NH 20900	CONCORD	CONTOCOOK 3	9.	838.	5308.	103.1
NH 2733	MILFORD	SOUHEGAN	7.	116.	734.	110.4
NH 3221	PEMBROKE	SUNCOOK RIV 6	16.	458.	2900.	111.3
NH 20901	CONCORD	ROLFE CANAL	12.	1103.	6986.	113.6
NH 20902	CONCORD	CONTOCOOK 4	7.	647.	4096.	114.5
NH 382	BELMONT	WINN.R. LKWINS	10.	473.	2796.	117.6
NH 4017	TILTON	WINNIPSKE R 2	12.	552.	3260.	121.4
NH 2129	LACONIA	LAKEPORT DAM	11.	439.	2595.	121.6
NH 236	BARNSTEAD	SUNCOOK RV 3	8.	100.	632.	123.0
NH 2681	MERRIMACK	MERRIMACK	18.	372.	2353.	123.3

Connecticut River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
NH 2293	LITTLETON	LITTLETON 1	15.	448.	2691.	21.4
NH 2203	LEBANON	MASCOMA R 8	15.	299.	1819.	21.9
NH 2199	LEBANON	MASCOMA R 4	11.	226.	1378.	22.7
NH 3312	PITTSBURG	LAKE FRANCIS	100.	2153.	12917.	32.2
NH 1896	HINSDALE	ASHUELOT R ONE	20.	1087.	6521.	37.1
NH 4405	WINCHESTER	ASHUELOT RIV	21.	1125.	6749.	40.0
NH 796	CLAREMONT	SUGAR RV ONE	28.	770.	4690.	48.6
NH 3104	NRTHMBRLND	U AMMONOOSC R2	13.	444.	2667.	53.7
NH 3103	NRTHMBRLND	U AMMONOOSC R1	11.	376.	2257.	58.1
NH 3953	SWANZEY	WILSON POND	18.	197.	1179.	82.4
NH 23883	SUNAPEE	SUGAR R 3	74.	374.	2281.	86.8
NH 4406	WINCHESTER	ASHUELOT RIV 2	18.	950.	5700.	88.9
NH 3038	NEWPORT	SUGAR RIVER 2	19.	155.	942.	94.4
NH 2608	MARLBORO	MINNEWAWA BK 3	65.	211.	1267.	94.7
NH 3037	NEWPORT	SUGAR RIVER 1	30.	198.	1206.	95.1
NH 2276	LISBON	AMMONOOSC RV 1	20.	749.	4493.	96.9
NH 3302	PITTSBURG	N.E.ELECT.SYTM	27.	290.	1742.	99.0
NH 314	BATH	AMMONOOSUC ONE	16.	680.	4081.	100.3
NH 3039	NEWPORT	SUGAR RIVER 3	17.	138.	843.	101.6
NH 3944	SWANZEY	ASHUELOT R	14.	579.	3473.	106.5
NH 2152	LANCASTER	GARLAND BROOK	7.	120.	722.	113.5
NH 4407	WINCHESTER	ASHUELOT RIV	16.	817.	4905.	119.7

Note: Any 5-digit dam number beginning with a "2" is a breached dam (e.g., CT 20835)

Piscataqua River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
NH	2763	MILTON	SALMON FALLS 2	99.	1493.	8958.	20.4
NH	2765	MILTON	SALMON FALLS 4	28.	411.	2468.	21.5
NH	3541	ROLLINGSFD	SALMNFALLSRIV2	45.	1345.	8073.	25.9
NH	3020	NEW MARKET	LAMPREY RIVER	36.	973.	5841.	30.7
NH	1151	DOVER	COCHECO RV FOU	34.	809.	4853.	34.2
NH	3707	SOMERSWORH	SALMON FALLS R	35.	996.	5979.	42.6
NH	3540	ROLLINGSFD	SALMONFALLRIVR	20.	604.	3624.	47.1
NH	2762	MILTON	SALMON FALLS 1	26.	395.	2373.	55.4
NH	21238	DURHAM	LAMPREY RIVER	30.	714.	4282.	57.5
NH	3516	ROCHESTER	COCHEO RIVER 2	18.	183.	1095.	86.2
NH	3515	ROCHESTER	COCHEC RIVER 1	25.	253.	1515.	110.9
NH	3708	SOMERSWORH	SALMON FALLS	17.	484.	2904.	115.0
NH	20272	BARRINGTON	ISINGLASS RI 3	30.	266.	1598.	123.4

No dams in the **New Hampshire Coastal Rivers** pass.

Rhode Island

70% Plant Factor, 15% Interest Rate

No dams in the **Narragansett Bay Drainage Area** pass.

Blackstone River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
RI	60	LINCOLN	ALBION	13.	732.	4391.	20.7
RI	56	WOONSOCKET	WOONSOCK FALLS	29.	1391.	8347.	37.7
RI	405	E PROVIDNC	HUNTS MILLS	10.	68.	409.	56.7
RI	59	LINCOLN	MANVILLE	19.	1062.	6373.	85.0
RI	66	PAWTUCKET	PAWTKET LOWER	17.	1056.	6338.	85.2
RI	63	CENTRAL FA	VALLY FALLS PD	14.	812.	4870.	94.2
RI	61	CUMBERLND	ASHTON DAM	11.	628.	3767.	103.3
RI	65	PAWTUCKET	PAWTKET UPPER	7.	435.	2610.	120.3
RI	62	LINCOLN	PRATT	15.	866.	5195.	121.2

Pawtuxet River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
RI	148	W WARWICK	ARTIC	24.	227.	1363.	23.0
RI	156	W WARWICK	PHENIX	12.	162.	970.	24.3
RI	145	WARWICK	NATICK POND	30.	702.	4210.	52.3
RI	158	COVENTRY	ARKWRIGHT MILL	20.	262.	1572.	69.9
RI	147	W WARWICK	RV POINT UPPER	30.	285.	1711.	71.3
RI	149	W WARWICK	CENTERVILLE PD	20.	188.	1129.	84.6
RI	157	COVENTRY	HARRIS MILL	25.	331.	1985.	89.3
RI	160	SCITUATE	HOPE	12.	152.	912.	96.9

Pawcatuk River Basin/Rhode Island Coastal Rivers

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
RI	249	RICH CHARL	HORSESHOE FALS	17.	205.	1229.	23.3
RI	247	HOPKT RICH	ALTON POND	15.	167.	1000.	24.2
RI	246	HOPKT RICH	WOODVILLE POND	9.	98.	588.	50.0
RI	253	WESTY HOPK	BRADFORD	8.	228.	1368.	121.2
RI	250	RICH CHARL	SHANNOCK	7.	85.	509.	124.1

No dams in the **Thames River Basin** pass.

Vermont

70% Plant Factor, 15% Interest Rate

Connecticut River Basin

DAM NUMBER		COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
VT	9518	SOMERSET	SOMERSET RES	104.	468.	2808.	8.9
VT	8801	SPRINGFILD	COMTU FALLS	30.	745.	4469.	20.7
VT	8766	SPRINGFELD	FELLOWS	13.	321.	1927.	22.0
VT	8780	WINDSOR	MILL POND	40.	228.	1367.	23.0
VT	4763	RYGATE	EAST RYGATE	8.	2304.	13822.	25.8
VT	24512	BARNET	RAY BROTHERS	30.	1977.	11864.	31.9
VT	8256	HARTFORD	EMERY MILLS	30.	800.	4797.	34.4
VT	8802	SPRINGFILD	GILMAN DAM	30.	745.	4469.	36.2
VT	9751	DUMMERSTON	W DUMMERSTON	26.	1599.	9594.	39.7
VT	8768	SPRINGFELD	LOVEJOY	10.	247.	1482.	40.8
VT	8254	HARTFORD	DEWEYS MILLS	40.	1076.	6458.	40.9
VT	7250	BRADFORD	BRADFORD	50.	994.	5967.	44.9

continued

Note: Any 5-digit dam number beginning with a "2" is a breached dam (e.g., CT 20835)

Connecticut River Basin (cont.)

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY KW	ENERGY MWH	ENGYCST MIL KWH
VT 8261	HARTLAND	HAMPSON	25.	731.	4387.	51.0
VT 8279	BETHEL	E BETHL SAWMIL	10.	82.	491.	53.0
VT 7253	NEWBURY	ADAMS PAPER CO	15.	165.	975.	93.3
VT 7254	NEWBURY	BOLTONVILL DAM	30.	310.	1833.	95.4
VT 8772	SPRINGFELD	SLACK	18.	445.	2668.	119.1
VT 8255	HARTFORD	DEWEYS MILS PD	15.	404.	2422.	124.8

Hudson River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
VT 9534	PAWNAL	TANNING COMP D	24.	792.	4752.	20.6
VT 9533	BENNINGTON	VERMONT TISSUE	16.	228.	1368.	75.6

Lake Champlain Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
VT 26255	BRISTOL	BRISTOL	110.	647.	3881.	8.9
VT 6755	MIDDLEBURY	MIDDLEBURY UPP	15.	1134.	6804.	36.4
VT 3	HIGHGATE	EAST HIGHGATE	11.	1069.	6415.	37.4
VT 9	SWANTON	SWANTON DAM	10.	1016.	6098.	38.2
VT 5250	DUXBRYWTRB	BOLTON FALLS	50.	5100.	30600.	39.5
VT 5519	E MONTPELR	MONTPELR FOUR	25.	603.	3618.	58.6
VT 8036	RUTLAND	RIPLEY MILLS	10.	368.	2210.	58.7
VT 2012	BURLWINOOS	AMERICAN WOOL	20.	2640.	15840.	61.0
VT 5752	MORETOWN	MORETOWN EIGHT	34.	530.	3182.	63.0
VT 23259	JOHNSON	VILOFJOHNSNDAM	40.	288.	1728.	71.7
VT 3253	HYDE PARK	GREEN R MAIN D	95.	160.	958.	85.8
VT 5522	MONTPELIER	DANIELS MILL	35.	294.	1764.	98.0
VT 5758	NORTHFIELD	NORTHFIELD ML	25.	186.	1116.	101.8
VT 3510	STOWE	SMITH DAM	14.	138.	827.	103.4
VT 26009	FERRISBURG	TURNER	30.	245.	1469.	114.8
VT 8054	BRANDON	NESHOBE	63.	159.	953.	118.3

St. Francis River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
VT 21011	IRASBURG	ALEXANDER	12.	88.	527.	28.2

Appendix B: Undeveloped Dam Sites

All undeveloped dam sites shown on the maps accompanying this report are listed in the following sections. The 44 sites listed were screened from a survey of over 1000 dam sites initially compiled by the New England Division, U.S. Army Corps of Engineers in the 1954 report of the New England-New York Inter-Agency Committee study, *The Resources of the New England-New York Region*. Sites were initially eliminated from further screening if creation of a new impoundment would conflict with other dams already in operation or potentially suitable for development. A computer screening for the remaining dams was then conducted using a methodology similar to that developed for the existing dams analysis summarized in Appendix A, with additional costs added for dam construction, land clearing, relocation, and other factors pertinent to new dam development. All projects were evaluated for an effective head of 85% of gross head, and were assumed to be capable of using all available flow for power generation. Gross heads were selected on the basis of optimal cost per kilowatt hour generated. Capacities listed were computed for a 70% plant factor.

Connecticut

70% Plant Factor, 15% Interest

Housatonic River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
CT 91719	KENT	KENT FURNACE	40.	4627.	28274.	69.9
CT 91722	NEW MILFRD	BOARDMAN	23.	3593.	21957.	71.2

Maine

70% Plant Factor, 15% Interest

St. John River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
ME 99022	WALLAGRASS	MILE 1 FISH R	23.	3167.	19354.	37.4
ME 99024	CASTLE HIL	WASHBURN	22.	5453.	33323.	57.3
ME 99004	T13 R14	SEVEN ISLANDS	33.	7397.	45203.	74.7
ME 99007	T14 R14	BIG BLACK RES	25.	2062.	12599.	98.8
ME 99023	MASARDIS	MASARDIS	33.	3034.	18544.	113.0

Penobscot River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
ME 99187	BRADLEY	MARSH ISLAND	15.	17167.	104907.	46.9
ME 99178	MATTAWAMKG	STRATTON	27.	6238.	38120.	54.6
ME 99190	BRADLEY OR	BASIN MILL DAM	5.	5898.	36044.	58.0
ME 99207	MEDFORD	CAMPBELL RIPS	20.	4216.	26350.	61.0
ME 99177	MATTAWAMKG	GORDON FALLS	20.	4284.	26180.	61.2
ME 99180	MATTAM ENF	MOHAWK RAPIDS	7.	5398.	32987.	67.8
ME 99154	T5 R8	POND PITCH	31.	2941.	17971.	74.1
ME 99179	CHEST WINN	WINN	5.	3718.	22720.	88.0
ME 99171	T2 R10	SOURDNAHUNK	53.	12245.	74828.	90.5
ME 99172	T2 R10	POCKWOCKAMUS	50.	11857.	72462.	96.3
ME 99163	T3 R7	BEAR RAPIDS	30.	4452.	27208.	100.7
ME 99200	SANG DOVFO	ABOVE FOXCROFT	20.	1190.	7437.	103.5

Kennebec River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
ME 99314	FORKS T1R4	THE FORKS	13.	4913.	30023.	47.5
ME 99319	MADISON	SOUTH MADISON	13.	6444.	39382.	54.2
ME 99315	T1R3 CARAT	CARRYING PLACE	30.	12577.	76857.	65.9
ME 99318	MADISON AN	ABOVE NO.ANSON	15.	6472.	39550.	69.1
ME 99309	T3R4	GRAND FALLS	35.	2924.	17868.	71.0
ME 99307	T1R5 WFORK	STEEPSIDE	53.	12731.	77801.	73.5
ME 99305	T1R7 T2R6	ABOVE INDIAN P	23.	4416.	26989.	86.7
ME 99313	WFORKST1R4	POPLAR FALLS	120.	15422.	94248.	95.9
ME 99350	PHILLIPS	ABOVE PHILLIPS	30.	668.	4176.	113.8

Androscoggin River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
ME 99462	DIXFD PERU	DIXFIELD	13.	4884.	30526.	54.2
ME 99454	GILEAD	PHILBROOK	15.	4207.	26297.	67.5
ME 99471	DURHM LISB	DONOVAN RIPS	11.	6152.	38452.	70.0
ME 99452	UPTON	U UMBAGOG LAKE	40.	3536.	22100.	78.3

Saco River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
ME 99555	STANDISH	STEEP FALLS	10.	2515.	15205.	75.9

Massachusetts

70% Plant Factor, 15% Interest

Connecticut River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
MA 99854	DEERF CONW	MEADOW	40.	4189.	25323.	52.0

New Hampshire

70% Plant Factor, 15% Interest

Merrimack River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
NH 9[illegible]70[illegible]	MERRIMACK	MOORES FALLS	35.	17136.	104720.	54.9

Connecticut River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
[illegible] 90985	CORN PLAIN	HART ISLAND	28.	20950.	124600.	50.1
NH 90986	CORNISH	CHASE ISLAND	24.	18349.	109128.	57.6
NH 90327	BATH	WOODSVILLE	27.	1744.	10373.	106.2

Vermont

70% Plant Factor, 15% Interest

Connecticut River Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
VT 99850	BRATTLEBORO	BRATTLEBORO	23.	1724.	10592.	57.0
VT 98383	HARTFORD	WEST HARTFORD	33.	3640.	21649.	73.7
VT 94600	LYNDON	LYNDONVILLE	47.	1670.	9932.	107.6
VT 98380	BETHEL	LOCUST CREEK	39.	1682.	10002.	111.8
VT 99413	NEWFANE	WILLIAMSVILLE	37.	2232.	13713.	112.0

Lake Champlain Basin

DAM NUMBER	COMMUNITY	PROJECT NAME	GH	CAPACITY (KW)	ENERGY (MWH)	ENGYCST MIL KWH
VT 93351	JOHNSON	JOHNSON	23.	1147.	7082.	103.5

Appendix C: Recreational and Scenic River Data

River	VALUES: Total Length	Primarily Unde-veloped	Scenic	Historic	Geologic	Ecologic	RECREATIONAL USE: Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Miles of white water: Class II	Class III	Class IV	Class V	# Dam Releases/Year	When Boatable	Flow Needed	Race River	Usage	COMMENTS
State of: CONNECTICUT																			
BANTAM RIVER Litchfield, CT to Shepaug River (WW: Bantam to Shepaug R.)	14 (5.4 WW)			X			X			X 5.0					March			Med.	Segment runs through Litchfield (National Landmark - unique example of 18th century town and former colonial tranding center). One of the early spring white water runs; good introduction to the season.
FARMINGTON RIVER Otis, MA to Windsor, CT. (WW: Otis, MA to New Boston; CT - Riverton to Collinsville, Collinsville to Unionville; Tariffville Gorge	65.25 (13 WW)		X		X		X	X	T	X 11.0	X 2.0			50 wks	All Year Long	770 low - 1900 cfs med	X	High	Known for high level of recreation use, all seasons of the year. Only southern New England river running throughout the summer. Used for canoe & kayak instruction, national international level races and commercial tubing. Close proximity to several urban centers. Geologic: unique land forms and topography.
HOUSATONIC RIVER Great Barrington, MA to New Milford CT	41		X	X		X	X								All Year Long	900 low - 3000 high	X	High	Wild and Scenic Study River. Generally free-flowing. Historic: picturesque homes, stores, stone fences, evidence of colonial settlement & role during 19th century iron producing period. Archeological: evidence of prehistoric cultures. Hosts State rare and endangered plants. Excellent family recreation river.
JEREMY/SALMON RIVERS N. Westchester, CT to CT River (WW: N. Westchester to Comstock Bridge, Route 16)	13 (5.6 WW)		X		X			X		X 4.75					March	220 low - 1500 med	X	High	Recreation: one of the early spring white water rivers. Good beginner training river. Site of national annual canoe slalom race. Geology: flows through geological fault lying under a series of cave formations; produces audible tremors.

River	VALUES						RECREATIONAL USE			Miles of white water									COMMENTS
	Total Length	Primarily Undeveloped	Scenic	Historic	Geologic	Ecologic	Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Class II	Class III	Class IV	Class V	# Dam Releases/Year	When Boatable	Flow Needed	Race River	Usage	
State of: CONNECTICUT																			
SHEPAUG RIVER Shepaug Resevoir (Warren, CT) to Lake Lillinonah (WW: [illegible] Woodville, [illegible] to Washington [illegible], CT)	26 (7.0 WW)		X	X	X	X	X	X			X 7.0				Late March	375 low- 600 med.	X	High	Wild and Scenic Study River. Substantially free-flowing, "evidence of civilization is minimal". Scenic qualities are diverse and represent the charm of southern New England. Rich in historic interest. Could yield significant archeological data. 10 acre stand of 200 hundred year old hemlock.
State of: MAINE																			
ALLAGASH RIVER Long Lake Dam to Confluence at St. John River	[illegible]4.25	X	X	X			X								Mid-May - July			High	New England's only national Wild and Scenic river. Managed by the State of Maine. National attraction for canoe expeditions. Historic logging run.
DEAD RIVER Flagstaff Lake to The Forks, ME (WW: Spencer Stream to West Forks)	22.75 (15 WW)	X	X	X				X	R	X	X			Summer &Fall 7 Releases	Spring Runoff Sum. Fall	800 - 1300 cfs Med.	X	High	Unique stretch of river, relatively remote. Longest stretch of Class II-III white water rapids in north east. Site of national canoe championships. All comments indicated Dead as a highly significant regional resource.
EAST BRANCH PENOBSCOT Telos Lake to Medway (WW: Intermittent through entire stretch)	81.5 (5.5 WW)	X	X			X	X	X		X 1.0	X 3.5	X 1.0		Spr. Fall (sum. fall rls.)	May-June	1000-3000 cfs		Low	Outstanding wildlife bald eagle, moose, black bear, deer and black duck. Excellent water quality. Wilderness white water recreation opportunity available during three seasons. High archeological potential. Primitive scenic qualities.

River	VALUES: Total Length	Primarily Undeveloped	Scenic	Historic	Geologic	Ecologic	RECREATIONAL USE: Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Miles of white water: Class II	Class III	Class IV	Class V	# Dam Releases/Year	When Boatable	Flow Needed	Race River	Usage	COMMENTS
State of: MAINE -continued																			
KENNEBEC Harris Dam at Indian Pond to Wyman Dam	25 (21.5 WW)	X	X	X				X	R	X 7.0	X 4.0	X 5.5	X 5.0	Five Days/Week	June-Sept.	1000-3000 cfs		High	Kennebec gorge known for remarkable beauty and size; no equal in the north east. One of two large volume water runs in New England. Similar to western river experience. Rafting on this stretch has grown tremendously; doubling annually over past few years.
MACHIAS RIVER Third Machias Lake to Whitneyville	50 (4.75 WW)	X	X		X	X	X	X		X 4.25	X .5				May			Med.	Rates as one of Maine's most scenic waterways. Second longest free-flowing river in Maine. Diverse features - lakes, swamps, rapids, ledges, waterfall. Extensive blueberry barrens and magnificent stands of white pine. Upper reaches are semi-wilderness.
NARRAGUAGUS RIVER Headwaters to Millbridge	54 (2.3 WW)		X				X			X 2.3					May			Med.	Numerous access points. Attractive and scenic. Excellent family canoe trip river.
NORTH BRANCH OF THE PENOBSCOT RIVER Headwaters to Pittst[illegible]	27 (3.5 WW)		X				X			X 3.5					May			Low	Early spring river. Dependent [illegible]

River	VALUES: Total Length	Primarily Undeveloped	Scenic	Historic	Geologic	Ecologic	RECREATIONAL USE: Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Miles of white water: Class II	Class III	Class IV	Class V	# Dam Releases Year	When Boatable	Flow Needed	Race River	Usage	COMMENTS
State of: MAINE - continued																			
RAPID Lake Richardson to Lake Umbagog	(4.5 WW)		X					X			X 4.5			Varies	Late Summ. Early Fall	800-1200 cfs	X	High	[illegible]
SACO RIVER NH Border to Hiram, Maine	40		X				X			X 2.0					Alwys			High	[illegible]
SHEEPSCOT RIVER Headwaters to Wiscasset	25 (6.5 WW)		X			X	X			X 4.0	X 2.5				Lower Section all Summer Upper to June 15				[illegible]
ST. CROIX RIVER Vanceboro to Kellyland	30 (.6 WW)		X				X			X .6					Spring thru Fall			High	[illegible]

River	VALUES						RECREATIONAL USE			Miles of white water									COMMENTS
	Total Length	Primarily Undeveloped	Scenic	Historic	Geologic	Ecologic	Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Class II	Class III	Class IV	Class V	# Dam Releases, Year	When Boatable	Flow Needed	Race River	Usage	
State of: MAINE - continued																			
ST. JOHN RIVER Fourth St. John Pond to Dickey	184.5 (24.25 WW)	X	X	X			X	X		X 24.25					Mid-May - June	8,000 to 14,000 cfs		Med	Extensive semi-wilderness area, no-where else equalled east of the Mississippi. Access is limited - no public roads. The St. John offers an alternative to the crowded Allagash trip. Freeflowing home of furbish lousewart. Extensive deeryards & plentiful wildlife.
WEST BRANCH OF THE PENOBSCOT RIVER Ripogenus Dam to Ambajejus Lake	21 (17 WW)	X	X		X			X	R	X 2.0	X 7.5	X 4.5	X 3.0	Daily	May-Sept.	1200-3000 cfs		High	W & S Study river. Ripogenous gorge-spectacular high walls; big water akin to Western Rivers. Rapids; Class III-IV continue for 17 miles. Rafting has doubled annually for past several years. Closed boat use is also increasing substantially.
PLEASANT RIVER Pleasant River Lake to Pleasant Bay	30		X	X	X	X	X											Med	Historic: Columbia Falls-3 Historic Sites. Ecologic - river flows through the Great Heath, Maine's largest freshwater-peatland. Great Heath is remarkable for its scientific wildlife, botanic, and recreational values. Unique flora. The Great Heath was formed by glaciers. Spring and fall - hosts migrating waterfowl.

River	VALUES: Total Length	Primarily Undeveloped	Scenic	Historic	Geologic	Ecologic	RECREATIONAL USE: Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Miles of white water: Class II	Class III	Class IV	Class V	# Dam Releases/Year	When Boatable	Flow Needed	Race River	Usage	COMMENTS
State of: MASSACHUSETTS																			
WEST BRANCH OF THE FARMINGTON RIVER Otis Resevoir to New Boston, MA	(7.4 WW)							X		X	X	X		2 week-ends Fall	Spring Run-Off Fall	350 low - 850 high	X	High	One of the few whitewater runs in the fall. Releases from this Reservoir provide flow. Only water available in southern New England at that time. Class IV at [illegible] to high water [illegible].
HOUSATONIC RIVER Below Great Barrington to Connecticut Border	14		X	X			X								Spring to Fall				Surrounded by the Berkshires on one side and the Taconic Mountains on the other: extremely scenic.
MILLERS RIVER South Royalston to Athol; Erving to Millers Falls	(13.5 WW)							X		X 6.5	X 7.0				Late March early April	920 low 2000 high cfs	X	High	Very popular spring run. Training site for international slalom and downriver competitors. Used extensively by area college programs.
NASHUA RIVER Fitchburg to New Hampshire Border	42		X	X			X	limited							Late Spring to Early Fall		X	Med.	The Nashua River has undergone a major cleanup and protective effort over the past 12 years. The Nashua River Watershed Assoc. has established a greenway of 47 miles along the river, consisting of 6000 acres. The Harry Rich Memorial State Forest consists of a unique white pine stand. Dams which exist in the corridor help to combat low flow problems.

River	VALUES						RECREATIONAL USE			Miles of white water									COMMENTS
	Total Length	Primarily Under-veloped	Scenic	Historic	Geologic	Ecologic	Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Class II	Class III	Class IV	Class V	# Dam Releases/Year	When Boatable	Flow Needed	Race River	Usage	
State of: MASSACHUSETTS - continued																			
NORTH RIVER Hanover to Scituate	13		X	X		X	X								Spring to Fall			High	The North River is the first Massachusetts designated scenic river for its natural, scenic, and recreational qualities. The North River Commission reviews all permit applications for development of the river corridor.
QUABOG RIVER Warren, MA to Route 67	(5.5 WW)							X		X 2.75	X 1.5	X .5			March thru May Fall Runoff	480 - 1000 cfs		High	One of the better canoeing and kayaking rivers in western Massachusetts. Very popular in the early spring. It holds its water well, and can be canoed after a heavy rain, even in the fall.
PARKER RIVER Georgetown to Newbury	13.4		X			X	X								All Year			Med.	One of the most famous ornithological areas in the United States. National Wildlife Refuge. Extensive dune ecosystem. Recreational canoeing link between Atlantic coast and Merrimack River. Segment is on Mass. Scenic River inventory. [illegible] shoreline owned by MA Fish and Wildlife and Federal government.
NORTH, MIDDLE & WEST BRANCHES OF THE WESTFIELD RIVER N- W. Cummington to Huntington; W - Beckett to Hungtington; W-Peru to Confluence with North Branch	(48.3 WW)		X		X			X		X 8.2	X 34.1	X 6.0		N.Br. has releases for races Fall	Spring Fall	1200-1500 cfs	X	High	The least major relatively undeveloped freeflowing river in southern New England. Challenging white water from easy to difficult. Releases from Knightsville Dam provide 1000-1500 cfs for major regional races annually. Chesterfield Gorge is a spectacular box canyon owned by the Trustees of the Reservations.

River	VALUES: Total Length	Primarily Under-veloped	Scenic	Historic	Geologic	Ecologic	RECREATIONAL USE: Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Miles of white water: Class II	Class III	Class IV	Class V	# Dam Releases/Year	When Boatable	Flow Needed	Race River	Usage	COMMENTS
State of: NEW HAMPSHIRE																			
AMMONOOSUC RIVER Twin Mountain to Route 116 above Littleton	(10 WW)		X					X	T	X	X	X			Late Spring Early Summer	1000 cfs	X	High	Used for whitewater training and safety instruction. Lower section below Pierce Bridge is runnable in the summer if sufficient water. Area below dam has the best rapids. Paddlers from throughout NE use these rapids.
ANDROSCOGGIN RIVER Errol Dam to Berlin	23 (5.7 WW)		X				X	X		X				Daily	Spring to Fall	1200-1500 cfs	X	High	The most important summer white water in New England because water level is sufficient for boating and safe for instruction. Used by camps, schools, outfitters, and clubs. Best white water is for 2.5 miles below Pontook dam.
ASHUELOT RIVER Marlow to Shaw's Corner (Route 12A)	(7.5 WW)		X					X			X 4.0	X 3.5			April	700 cfs		High	Popular white water run for intermediate and advanced boaters. The middle section (Gilsum Gorge to Shaw's Corner) is valueable for instruction The lowest section (Ashuelot to Hinsdale) has several dams and is no longer a popular run.
BEARCAMP RIVER Bennett Corners to Whittier	(3.5 WW)		X					X		X 1.0	X .75	X .75			April	500 - 700 cfs		High	Small popular White Mountain river for both open and closed boats. Completely dependent on run-off for flows.

River	VALUES						RECREATIONAL USE			Miles of white water									COMMENTS
	Total Length	Primarily Under-veloped	Scenic	Historic	Geologic	Ecologic	Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Class II	Class III	Class IV	Class V	# Dam Releases/Year	When Boatable	Flow Needed	Race River	Usage	
State of: NEW HAMPSHIRE - continued																			
BLACKWATER RIVER Blackwater Flood Control Dam to Contoocook River	(10 WW)		X					X			X	X		COE Flood Control Dam Release	Spring	500 cfs		Low	Short, but very challenging run upon water release. The run requires expert skills. The difficulty of the run has limited the number of paddlers, but use is increasing annually.
CONNECTICUT RIVER Pittsburg to North Stratford	33.7		X				X			Some X					Spring - Fall			Med - Low	Buccolic, pleasant family canoe trip section. It is least developed and most scenic section of the Connecticut.
CONTOOCOOK RIVER Hillsboro to Henniker	(6.2 WW)		X					X	T		X 1.0	X 2.2			April to June runoff	1500-2000 cfs		High	The Contoocook is one of New Hampshire's best known rivers and offers some of the best heavy water boating in all New England. Local students train for slalom racing. Can rise to an acceptable level after heavy rains.
EAST BRANCH OF THE PEMIGEWASSET Headwaters to just above the confluence with Pemi. WW: Kancamagus HWY to just above Pemi	30 (5.5 WW)	X	X		X			X			X 3.0	X 2.5			April-May	1500 low - 3400 high		High	Corridor and surrounding watersheds are virtually undeveloped and remote. Spectacular mountain vistas. As the largest river in the area, spring run-off provides a unique and challenging run. Rapids are continuous and technical.

River	VALUES						RECREATIONAL USE			Miles of white water									COMMENTS
	Total Length	Primarily Undeveloped	Scenic	Historic	Geologic	Ecologic	Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Class II	Class III	Class IV	Class V	# Dam Releases/ Year	When Boatable	Flow Needed	Race River	Usage	
State of: NEW HAMPSHIRE - continued																			
MAD RIVER Waterville Valley to Pemigewasset River	(14.5 WW)		X					X			X 3.5	X 7.5			Mid-April		X	Med.	The flow is entirely dependent upon run-off: its season for boating is sporadic and short. However, when the level is high, it is a spectacular white water run. Races are held below the dam in Campton.
MASCOMA RIVER Mascoma Lake to Lebanon	(5.5 WW)		X					X		X	X			Fall Lake Draw-down	April May & Fall		X	High	Scenic and challenging run. Home river for Dartmouth College paddlers. Many national or world-class racers train on this section each year. Hosts international competitions. Rapids are entirely Class II at low water and Class III at medium to high water.
MERRIMACK RIVER Confluence with Soucook to Suncook River	27		X				X			X 1.0					April - May				Pleasant winding stream with a good current and largely undeveloped banks. Close proximity to urban Concord, New Hampshire.
OTTER BROOK East Sullivan to Otter Brook State Park	(3.25 WW)							X			X 1.0	X 2.25			Spring	300-350 cfs		High	Small, but popular run in the spring. Run is dependent on run-off: therefore, season is short.

River	VALUES						RECREATIONAL USE			Miles of white water									COMMENTS
	Total Length	Primarily Undeveloped	Scenic	Historic	Geologic	Ecologic	Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Class II	Class III	Class IV	Class V	# Dam Releases/Year	When Boatable	Flow Needed	Race River	Usage	
State of: NEW HAMPSHIRE - continued																			
SOUTH BRANCH OF THE PISCATAQUOG New Boston to Goffstown	(7.5 WW)							X		X 5.5					March - Early April			High	Popular early season run. Used extensively for instruction.
SACO RIVER Headwaters to New Hampshire/Maine Border (WW: Davis Path to Bartlett)	42 (7.25 WW)		X		X		X	X		X	X	X			Spring to Fall WW: April to June	700+ cfs	X	High	The watershed valley of the Upper Saco is one of the most scenic in all New England. Crawford Notch, a 10-mile scenic gorge, is one of the most scenic in New England. Lower section provides excellent canoe trip opportunity and runs all summer. The white water run is one of the most scenic. A race is frequently held at the lower part of the white water run.
SMITH RIVER Route 104 to Bristol	(8.0 WW)							X			X 2.5	X 2.25			April			Med.	Due to its short season, the Smith receives only moderate use. However, it is a standard spring run for many boating groups.
SOUHEGAN RIVER Greenville to Wilton	(3.5 WW)							X		X 3.5	X 2.0				Early Spring	300+ cfs		High	Usually the first river canoed in New Hampshire in the spring. Often used for instruction.

River	VALUES: Total Length	VALUES: Primarily Undeveloped	VALUES: Scenic	VALUES: Historic	VALUES: Geologic	VALUES: Ecologic	RECREATIONAL USE: Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Miles of white water: Class II	Class III	Class IV	Class V	# Dam Releases/ Year	When Boatable	Flow Needed	Race River	Usage	COMMENTS
State of: NEW HAMPSHIRE - continued																			
SWIFT RIVER Rocky Gorge on Kancamagus HWY to Kancamagus Estates	(8.5 WW)		X					X	R	X	X	X			Spring Runoff		X	High	New Hampshire's premier covered boat run. One of New England's five best white water rivers, offering one of the challenging and technical urns. The Swift "Race Course" is internationally known.
SWIFT DIAMOND RIVER Headwaters to Confluence with Dead River	18 (9.5 WW)	X	X				X	X		X 8.5	X 1.0				Early May			Low	Relatively inaccessible and remote. One of the few remaining wilderness rivers. Spring run-off provides a short canoeing season.

	VALUES						RECREATIONAL USE			Miles of white water									COMMENTS
River	Total Length	Primarily Undeveloped	Scenic	Historic	Geologic	Ecologic	Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Class II	Class III	Class IV	Class V	# Dam Releases/Year	When Boatable	Flow Needed	Race River	Usage	
State of: RHODE ISLAND PAWTUCKET RIVER Hundred Acre Pond to Route 3 beyond Bradford	28		X	?	X		X								March to June			High	Second best canoeing river in Rhode Island. Segment passes through site of historic battle of Narragansett Indians. Supports canoeing for four months. Passes through the Great Swamp-largest swamp in (National Nature Landmark). Close to major urban center. Only river in state with long unobstructed views, bordered by largely undeveloped land.
WOOD RIVER Northern limits of Arcadia Management Area to Alton	16.5 (.5 WW)		X			X	X			X .5					Year Round	150 + cfs		High	Considered the best canoeing river in RI. This clean river flows alternately through thick brush, laurel, oaks, and pines. Flows through the Arcadia Management area. Canoeable all year round. Close to major urban centers.

River	VALUES: Total Length	Primarily Undeveloped	Scenic	Historic	Geologic	Ecologic	RECREATIONAL USE: Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Miles of white water: Class II	Class III	Class IV	Class V	# Dam Releases/Year	When Boatable	Flow Needed	Race River	Usage	COMMENTS
State of: VERMONT																			
BATTEN KILL RIVER Manchester to Arlington, including Roaring Branch and Lye Brook	28	X	X	X		X	X								Spring & Summer (sometimes)			Med	Segment parallels historic Indian water route. Branch Pond, an unspoiled upland pond is surrounded by extensive primitive landscape. Clear water provides many opportunities for swimming.
CONNECTICUT (interstate) South Newbury to Confluence with Omponpanoosuc	37		X				X								All Year Long			Med	One of the more interesting and scenic sections of the Connecticut. Widely used for boating. Covered bridge at South Newbury.
GREEN RIVER Headwaters to Massachusetts Border	12		X				X								Spring Run-Off			Med	Unusually beautiful steam: "a delight to a nature lover". Scenic qualities are unique.
MAD RIVER Waitsfield to the Winooski River	14.5 (.75 WW)		X				X			X .5	X .25				April to Mid-May			Med	Significant boating river. Known for scenic qualities.

River	VALUES: Total Length	Primarily Under-veloped	Scenic	Historic	Geologic	Ecologic	RECREATIONAL USE: Flatwater Canoeing	Whitewater Canoeing	Rafts (R) Tubes (T)	Miles of white water: Class II	Class III	Class IV	Class V	# Dam Releases/ Year	When Boatable	Flow Needed	Race River	Usage	COMMENTS
State of: VERMONT - continued																			
OTTER CREEK South of Middlebury to Florence	100 (1.5 WW)		X	X			X			X 1.0	X .5				Spring Summer				Scenic views [illegible] and Adirondack Mountains. Hist[illegible] river is [illegible] former Indian canoe [illegible]. Pleasant canoe trip, scenic, runnable when most [illegible] rivers are [illegible]. The last remaining [illegible] in that area of the state [illegible]
WEST RIVER Ball Mountain Dam to Route 100	(6.1 WW)		X					X	X	X	X			(Of 2-3 wkends per year)	On Releases	1100-1500 [illegible]	X	High	Most [illegible]. Attracts paddlers [illegible] and other [illegible] increase [illegible]. [illegible]
WHITE RIVER Headwaters to South Royalston	37 (11.5 WW)		X				X			X 11.5					Spring to Summer	1,500		High	[illegible]

Appendix D: Sources of Mapped Data

Data used to produce the maps of anadromous fisheries, freshwater fisheries, and scenic and recreational rivers was collected from state and federal agencies, private interest groups, interested individuals, and published sources. The major sources of data for each map are as follows:

Anadromous Fish

U.S. Fish and Wildlife Service, Region 5
National Marine Fisheries Service
Maine Department of Inland Fish and Wildlife
Maine Department of Marine Resources
Massachusetts Division of Fish and Wildlife
International Atlantic Salmon Foundation
Trout Unlimited

Freshwater Fish

Trout Unlimited
Rhode Island Division of Fish and Wildlife
New Hampshire Department of Fish and Game
Massachusetts Division of Fish and Wildlife
Connecticut Department of Environmental Protection

Scenic and Recreational Rivers

Agencies

U.S. Department of the Interior, Heritage Conservation and Recreation Service — *Final List of Potential Wild and Scenic Rivers*, July, 1980.
Commonwealth of Massachusetts, Executive Office of Environmental Affairs, Department of Environmental Management
State of New Hampshire, Office of State Planning, *Wild, Scenic and Recreational Rivers for New Hampshire*, 1979.
State of Rhode Island, Department of Environmental Management, Division of Planning and Development.

Organizations — Commercial Outfitters

New England Rivers Center
Massachusetts Audubon Society
Connecticut River Watershed Council
Vermont Natural Resources Council
Appalachian Mountain Club
Saco Bound/Northern Waters
Northern Whitewater Expeditions, Inc.
Rhode Island Canoe Association
American Canoe Association, Eastern Division
New York Chapter, Appalachian Mountain Club
Northern Canoe Cruisers
Connecticut Canoe Racing Association

Sunrise County Canoe Expeditions, Inc.
Boston University Sargent Camp
Society for the Preservation of New Hampshire Forests
Maine Audubon Society
Deerfield Valley Conservation Association
Natural Resources Council of Maine
AMC Boston Chapter Canoe Committee
Merrimack Valley Paddlers
Hampshire College Recreational Athletics Program

Individuals

James Chute, Freeport, ME
Roy R. Schweiker, Concord, NH
Ray Gabler
Mrs. L. Baderhausen
Phil Schmidt
Ken Stone
Robert E. Manning

References

Appalachian Mountain Club, *River Guide*. Central/Southern New England.

Appalachian Mountain Club, *River Guide*, Northeastern New England.

Gabler, Ray, *New England Whitewater River Guide*. Tobey Publishing Co., Inc., 1975.

Schweiker, Roioli, *Canoe Camping — Vermont & New Hampshire Rivers*. New Hampshire Publishing Co., 1977.

Appendix E: FERC Licensing Process

The following is a brief summary the FERC licensing process. The FERC Office of Electric Power Regulation (OEPR) published a detailed guide to the licensing process in March, 1981. Copies of this publication, *Procedures to Apply for Hydropower Licenses and Permits*, can be obtained from OEPR, at the Federal Energy Regulatory Commission, 825 N. Capitol Street, NE, Washington, D.C. 20426.

Preliminary Permits

Principally, the preliminary permit provides a potential developer the assurance that his project will receive priority consideration for licensing while he studies its feasibility. Permits for existing site development are generally granted for a period of two years, new construction projects are given up to three years. This period provides an opportunity for the developer to consult with appropriate state and federal agencies and to prepare the required engineering, economic, and environmental data. The developer must apply for a license before the permit expires, or he will lose his priority status. (See competing applications.)

Licenses

The FERC review of license applications, both major and minor provides a forum for developers, government, and private interests to surface, negotiate, and resolve controversies surrounding a particular project. A developer does not need to hold a preliminary permit in order to seek a license.

Short form licensing, designed to expedite the review process, is now available for projects at both existing and new dams sites with a proposed capacity of less than 5 Mw. New dam construction or changes in impoundment size at existing dams, would require more detailed environmental reports. If there are no objections to the project, the licensing process can be completed in nine months to a year.

Major projects (over 5 Mw of proposed capacity) must pursue a more rigorous licensing review process. Depending on the scope of the project up to twenty-three exhibits, plus an in-depth environmental report must accompany significant project applications. Without major protest the process can be completed within a year. Conflict resolution can extend the process for two or more years.

Exemptions

Under the 1980 Energy Security Act, FERC was granted the authority to exempt projects of 5 Mw or less on either a case-by-case or class basis for owners of potential hydro sites.

Case-by-case review has now been instituted for projects with less than 5 Mw capacity. These projects must utilize an existing dam and operate in a run-of-river mode. Exemption applications are circulated to relevant federal agencies for a 60-day review period. Requirements for fish passage and minimum flows submitted by the U.S. Fish and Wildlife Service automatically become a condition of a granted exemption. The FERC review is designed to be completed within 120 days of receipt of the application.

Categorical exemption regulations are presently under consideration for two categories of projects — existing dams with capacity of less than 100 kilowatts (micro hydro projects) and existing dams with less than 5 Mw of capacity. The second category is further defined as having no change in impoundment size, no adverse impact on water quality, no diversions greater than 300 feet, no migrating fish species, and no historic or archeological sites. A certification of no impact by all relevant federal and state agencies will be required as part of the exemption application. U.S. Fish and Wildlife requirements become an automatic condition of the exemption.

The Energy Security Act specifically limits FERC's authority to exempt projects of less than 5 Mw. Any further exemptions would require Congressional action. Senate bill S1299 is presently under consideration to authorize a 15 Mw exemption.

Competing Applications

During the comment period, prior to issuing a preliminary permit or license, any party can submit a competing application for a particular site. FERC's rules and regulations provide that if there is competition between a preliminary permit application and a license application, that the license application will be favored. If there is competition for a preliminary permit or a license, the following applies: if both are public entities, the best plan is favored. If both are public entities, or both are private developers, and the plans are equal, then FERC will favor the first to file. If a public entity files a plan equal to a private developer's plan, the public entity will be favored. In a license application, however, if a private developer holds a preliminary permit, he is considered a priority applicant and FERC will favor him above all others. Since exemptions can only be granted to project owners, competing exemption applicants will not occur. However, if an exemption application is filed during the comment period of a preliminary permit or license application, the exemption application will be favored.

Comments/ Intervention

Persons who have an interest in a particular site may participate in the FERC proceedings in two ways - comment or formal intervention. Anyone may comment on a project during the protest and comment period (*delineated in the Federal Register notice*) of a preliminary permit application or a license application. These comments are considered by the FERC staff and the Commission. Comments, however, do not afford access to all aspects of the licensing proceedings, only formal intervention can provide that status. If a government agency or other intervenor does not represent the *same* interests of a commentor, those interests will not receive the same consideration that intervention would assure.

Any intervenor may request an administrative hearing on issues of fact. FERC makes the final decision to hold a hearing. Notice of a hearing opens the door to intervention by others who had not been parties to the proceeding up to that time. The result of any hearing and FERC's review of the application are published in the Federal Register along with the final articles of a license. At this time, a 30-day period is provided for the appeal of the decision for rehearing by FERC. Only intervenors can make this appeal.

If an intervenor is still aggrieved by a FERC decision, appeal can then be made to the U.S. Circuit Court of Appeals. This appeal is delineated in Section 313(b) of the Federal Power Act (16 U.S.C. 825 1 (c)(b)).

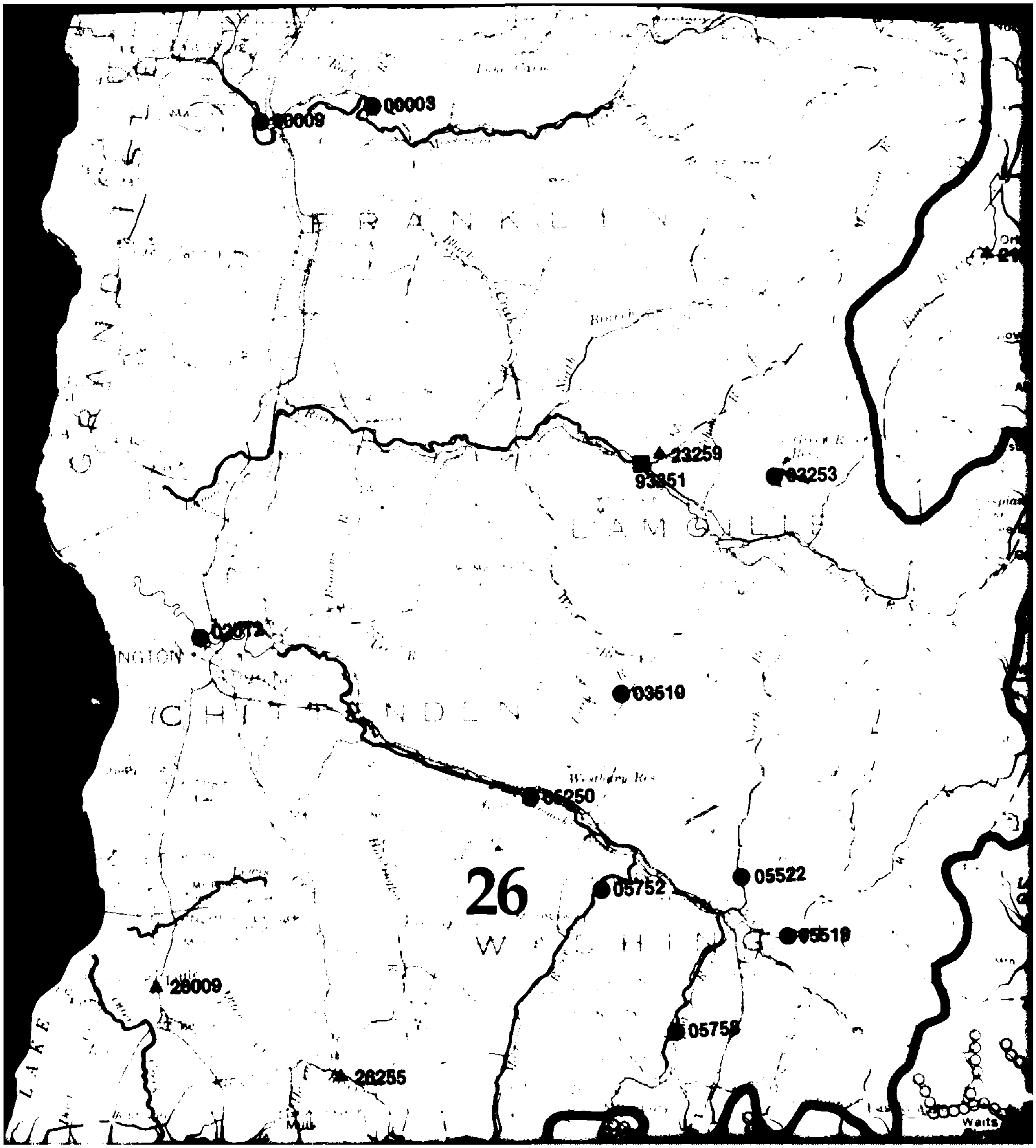
Water, Watts, and Wilds

Hydropower and Competing Uses in New England

The Final Report of the New England River Basins Commission's Hydropower Expansion Study August, 1981

MAPPED DATA

*See: Note at bottom of page 12



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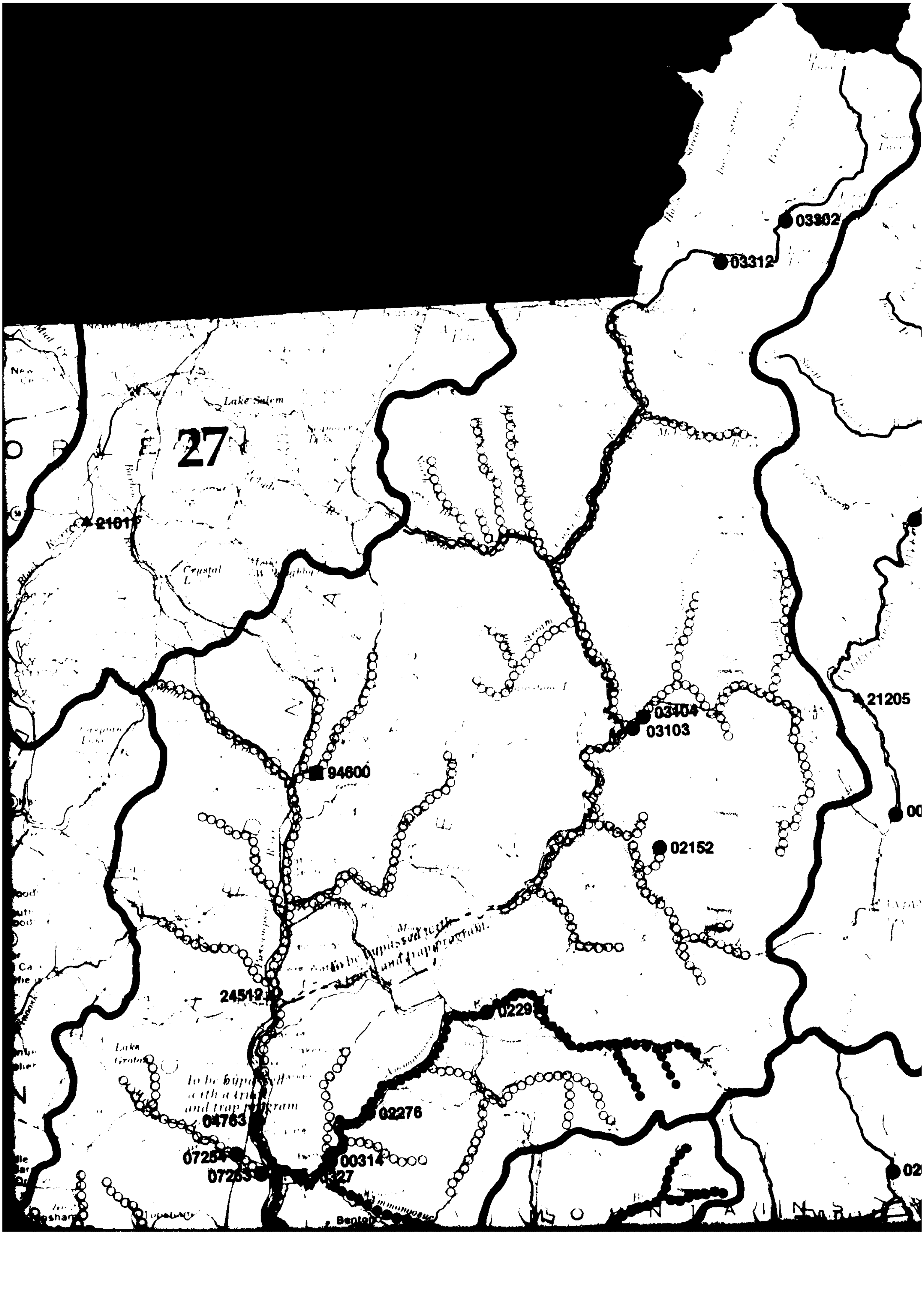
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Lake Salem
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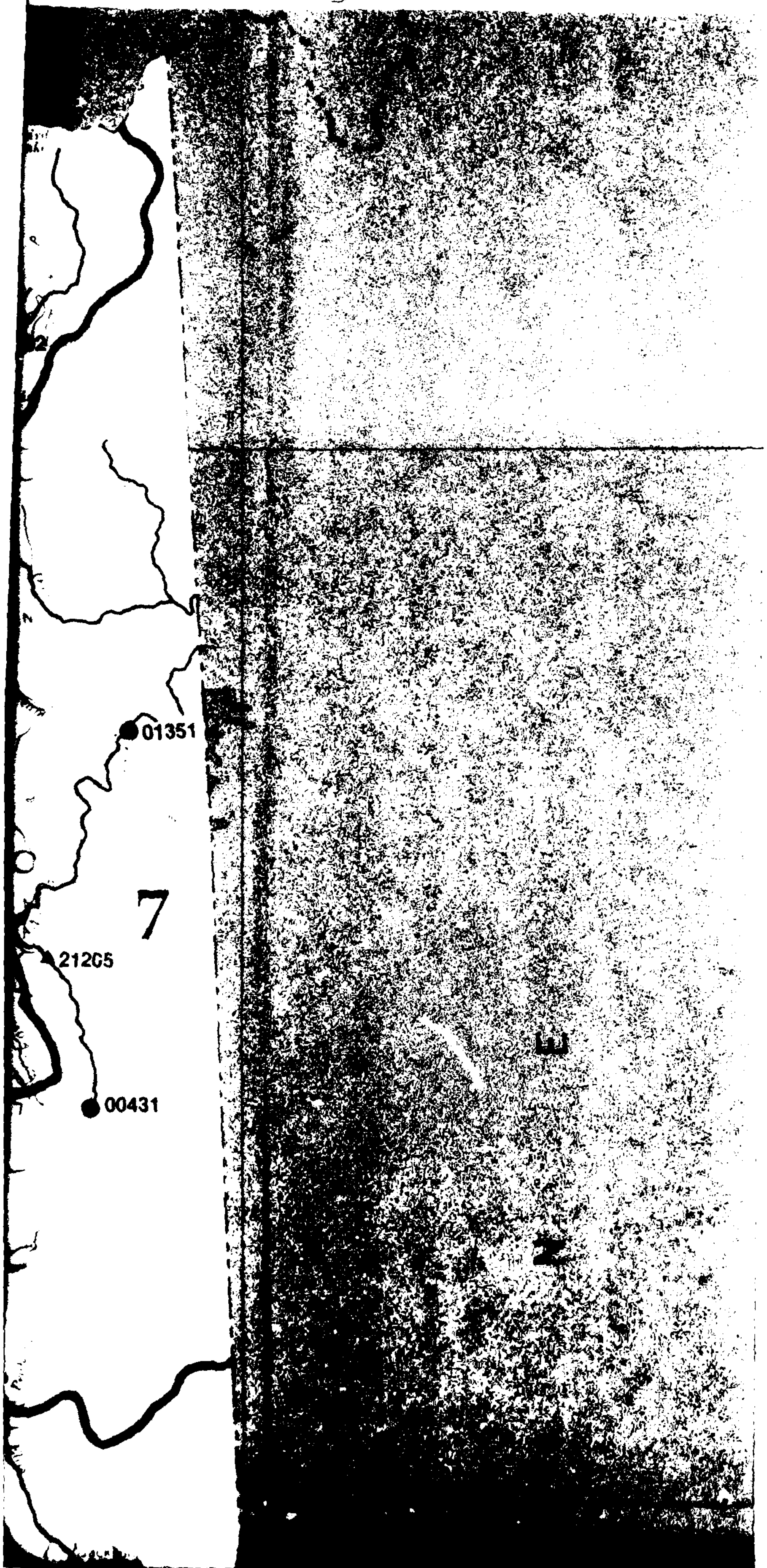
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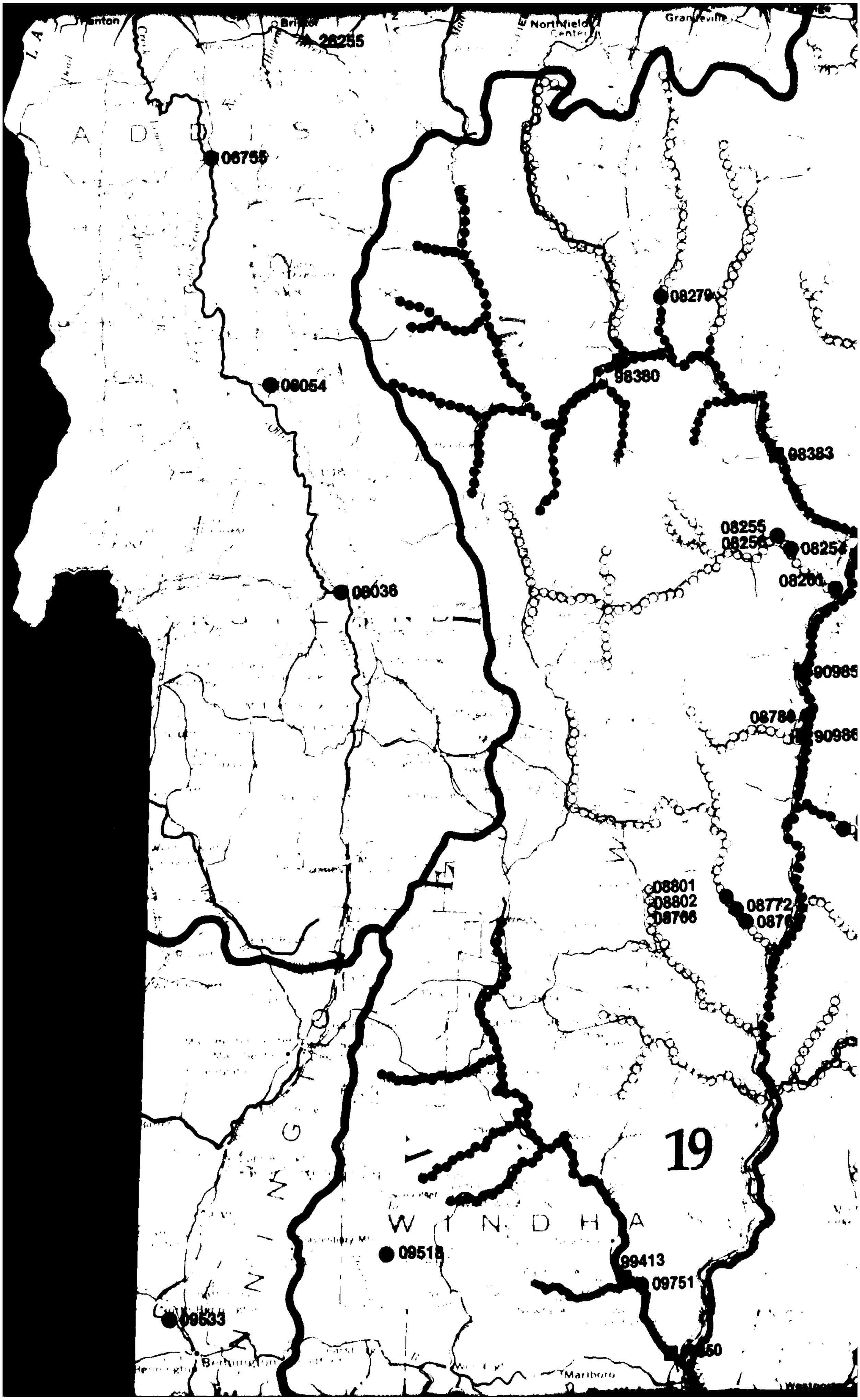

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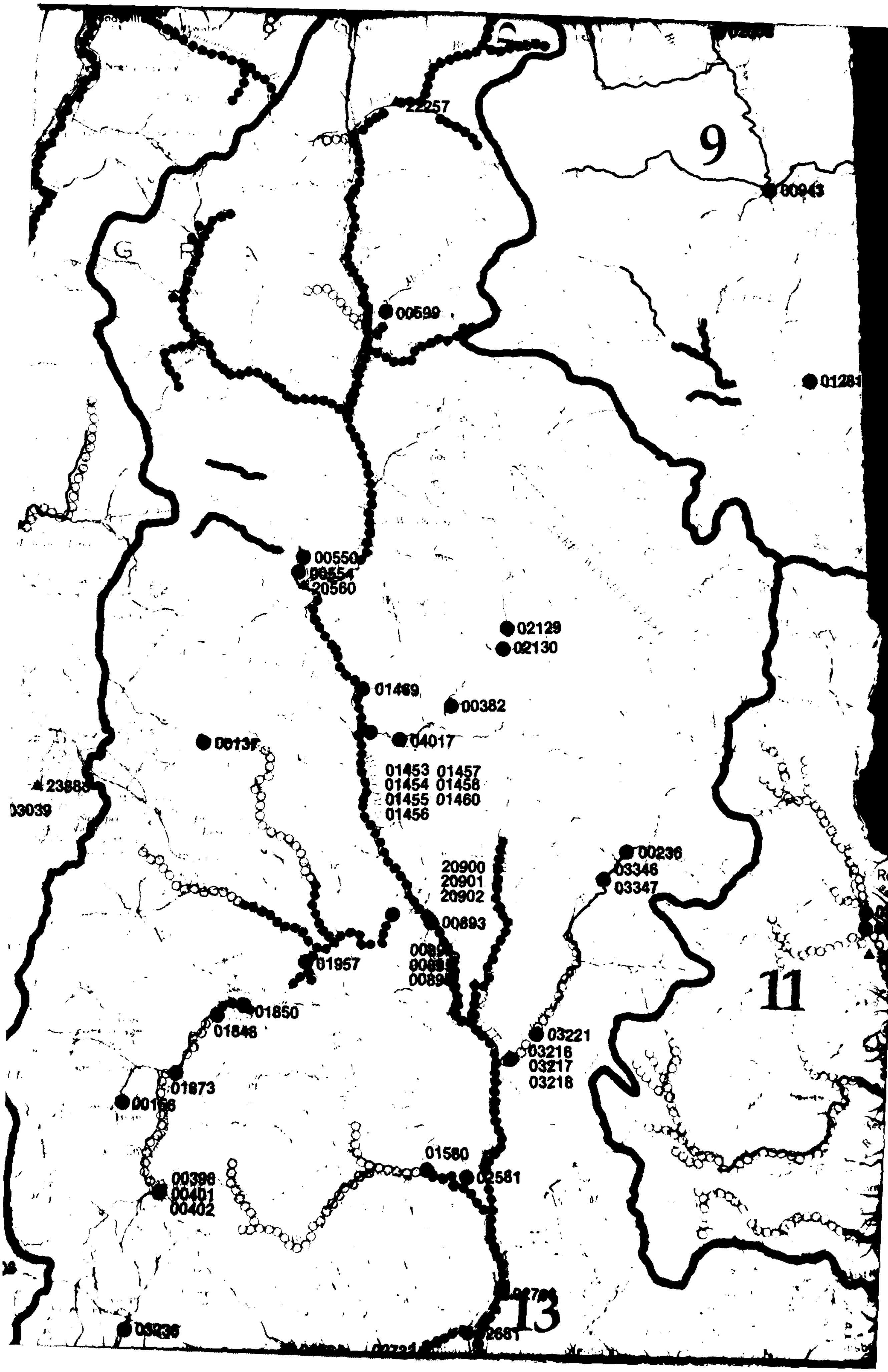
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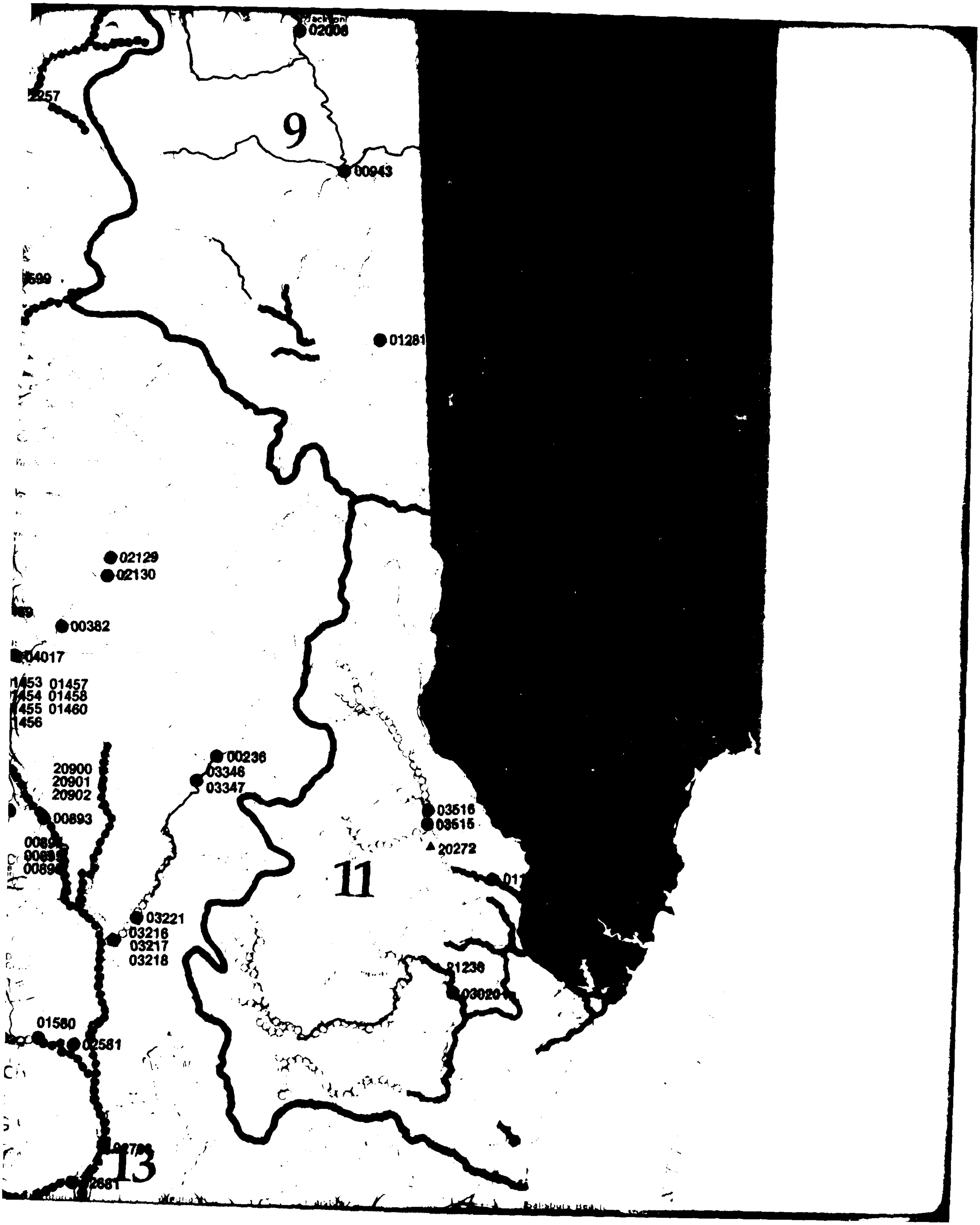
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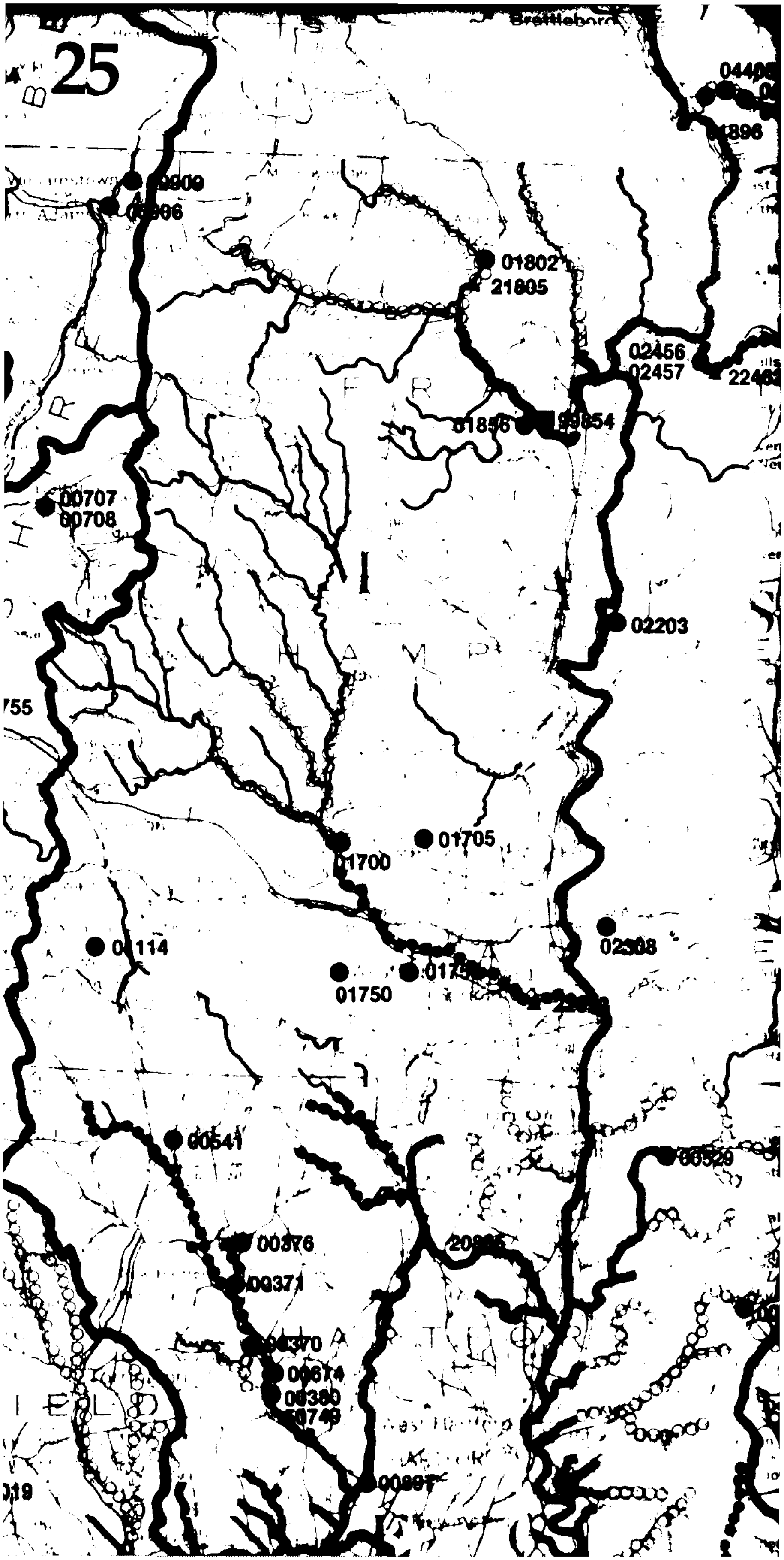
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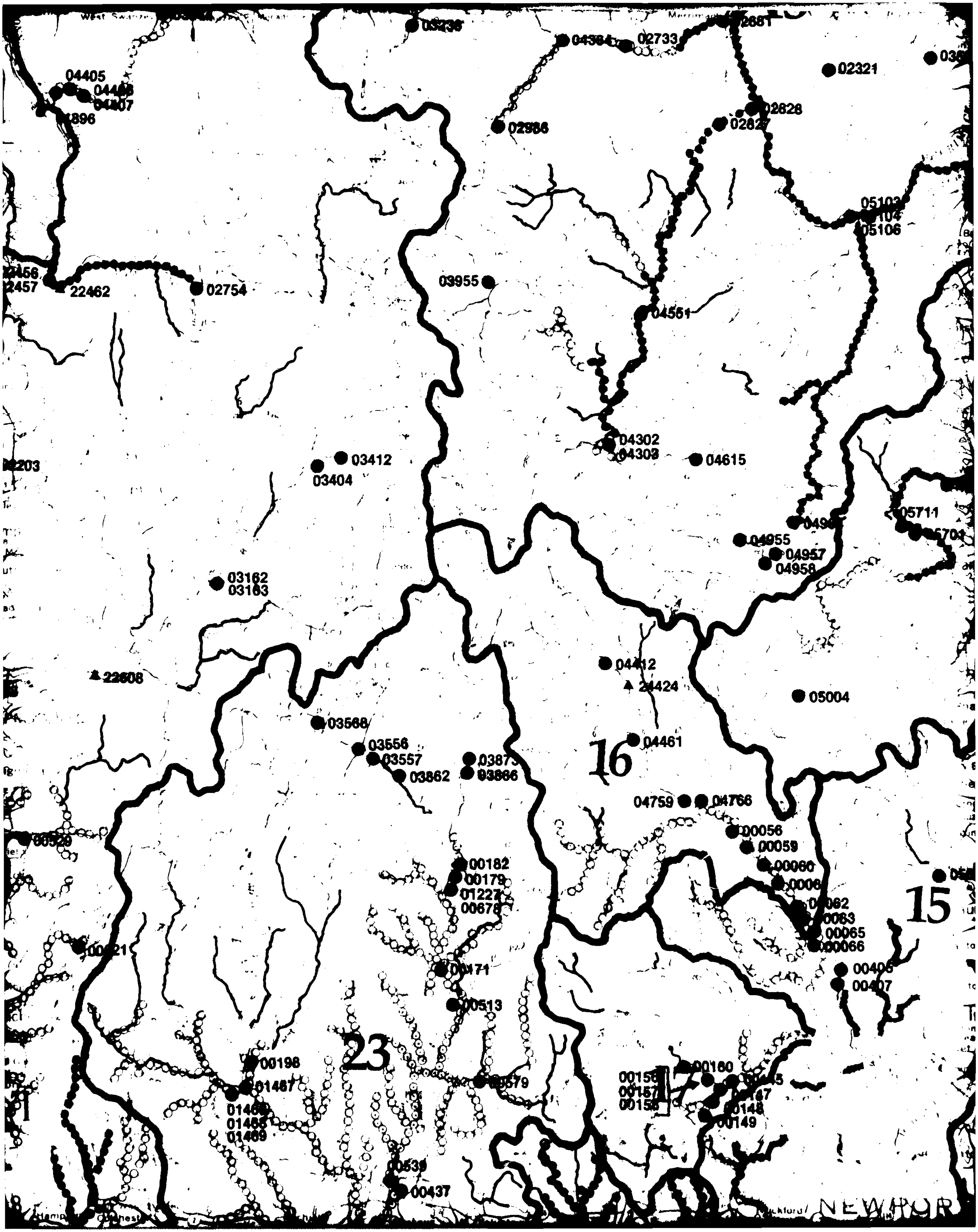

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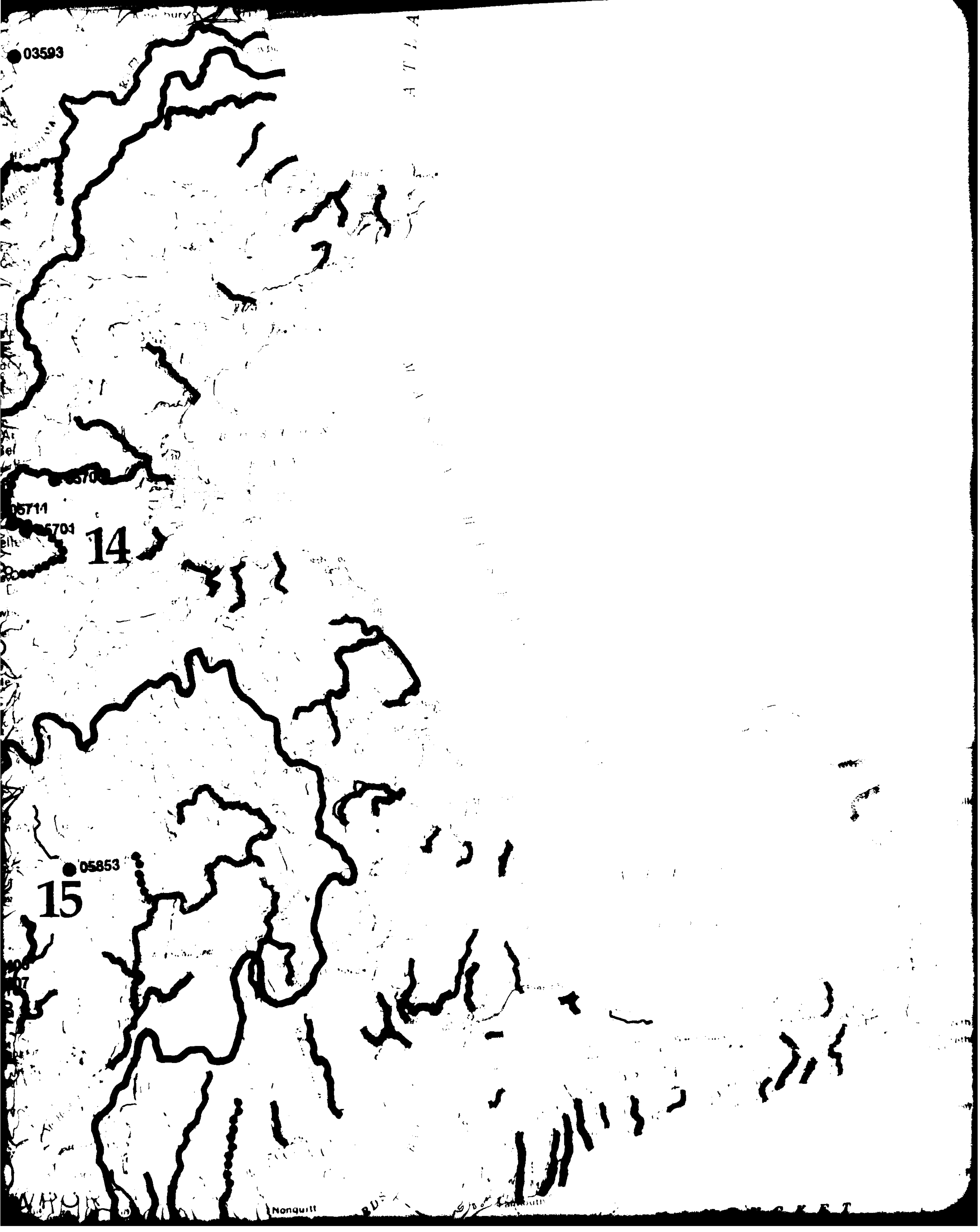
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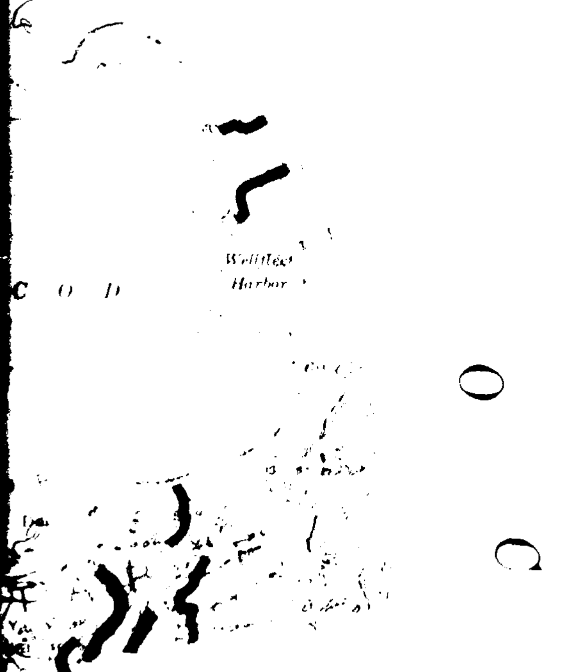

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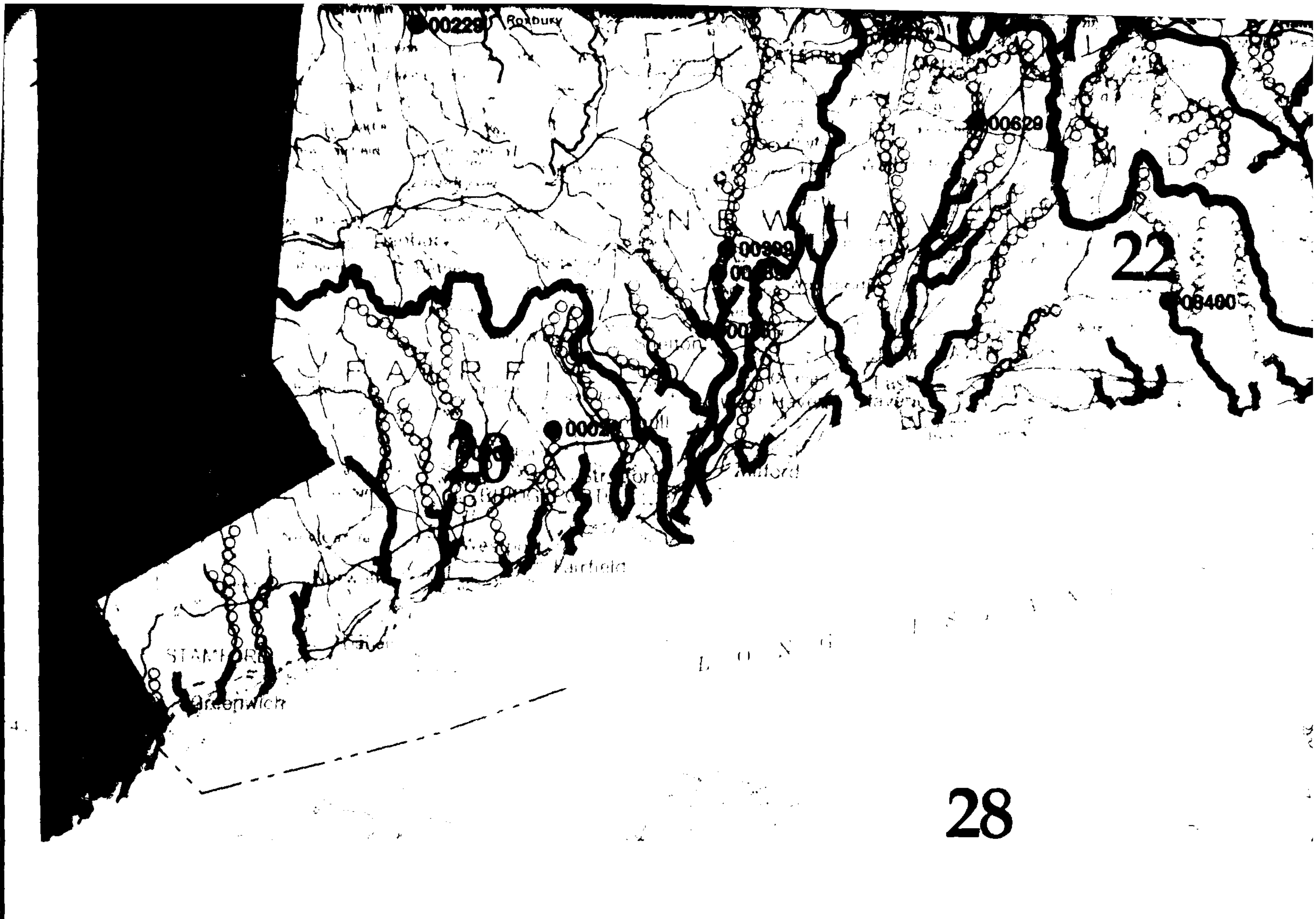

Potential Hydropower Sites:

● Existing dam
▲ Breached dam
■ Undeveloped site

Numerical Code

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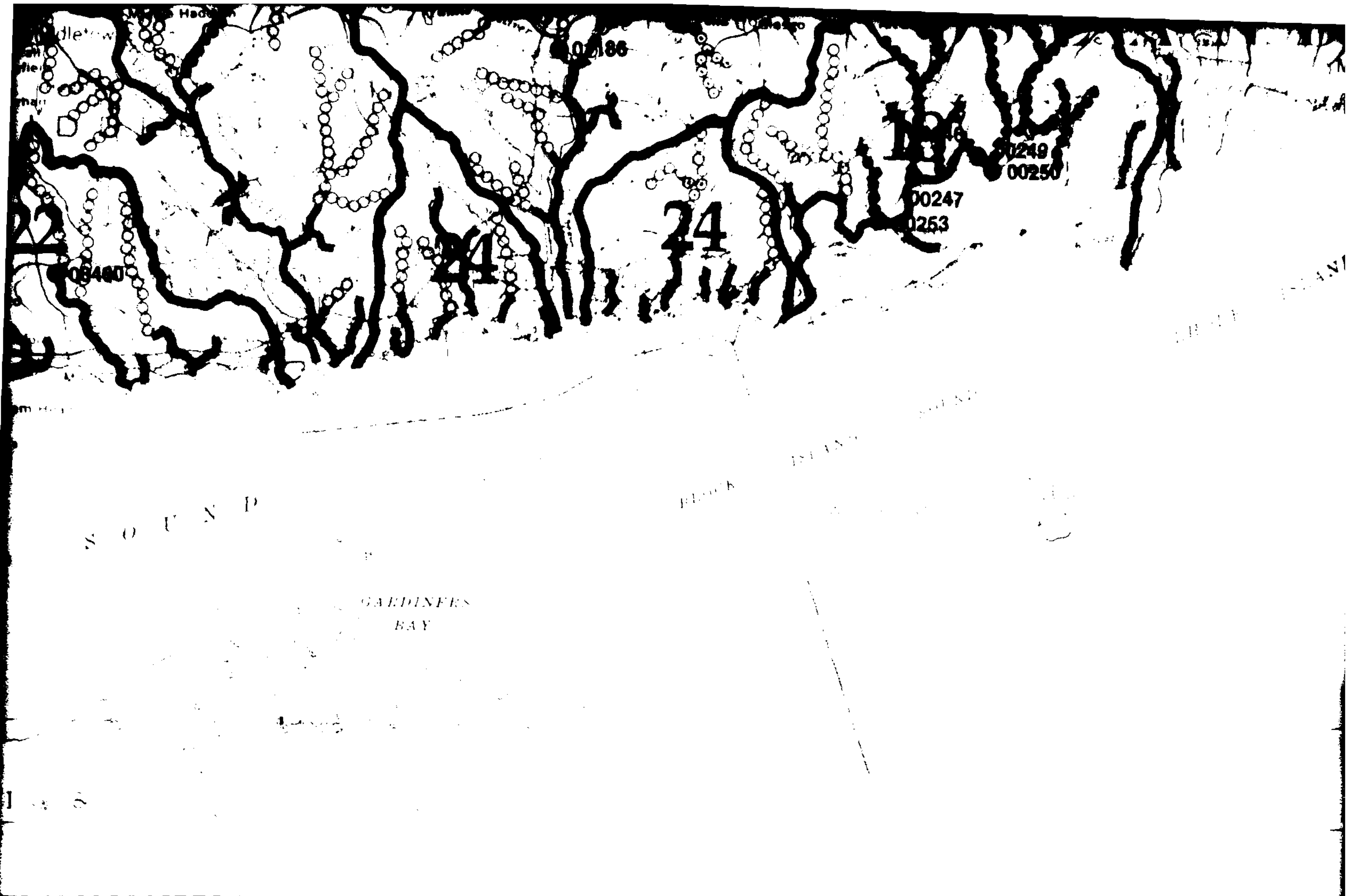

2 Fishery Resourc

Freshwater Fish

Important cold water fisheries

Anadromous Fish Runs

Existing

Currently under active restoration

Proposed for future restoration (Connecticut only)

Potential with inaccessible habitat

Data Source:

Appendix D of *Water, Watts, and Wilds; Hydropower and Competing Uses in New England*

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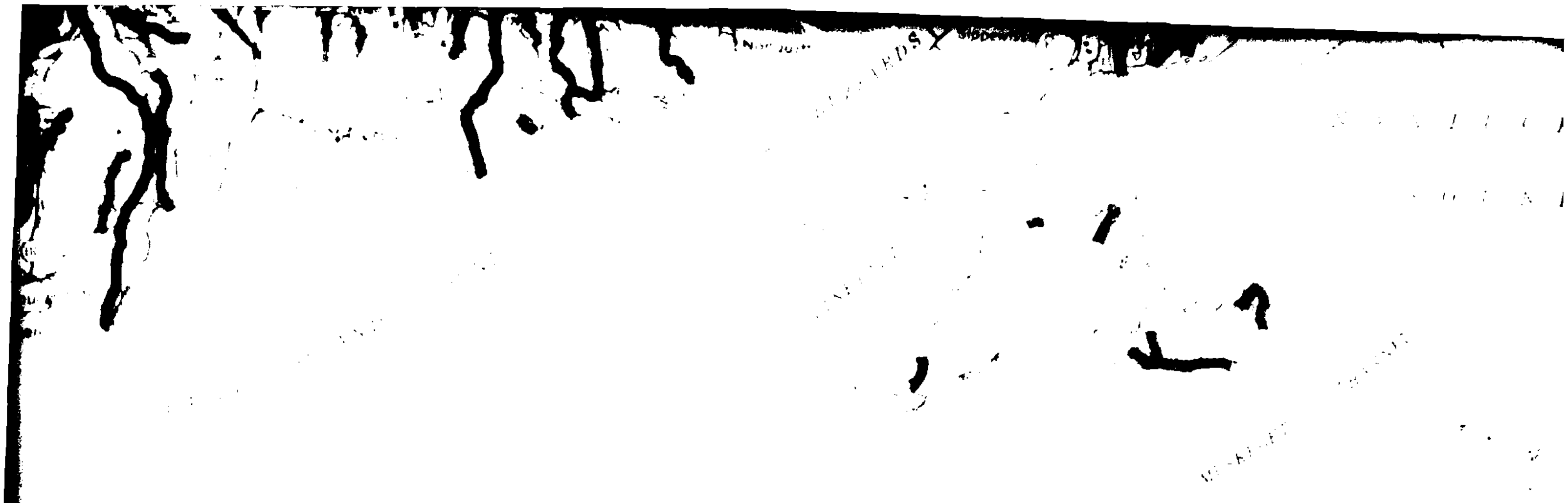

Resources

Anadromous Fish Data
Anadromous fish data for the Connecticut and Merrimack River Basins reflects the results of state federal planning for anadromous fish passage as described in the Final Merrimack River Basin Fish Passage Action Plan and the Draft Connecticut River Basin Fish Passage Action Plan.

Anadromous Fish in Vermont
Information on the anadromous fish resources of Vermont is only available for the Connecticut River Basin although anadromous fish occur elsewhere.

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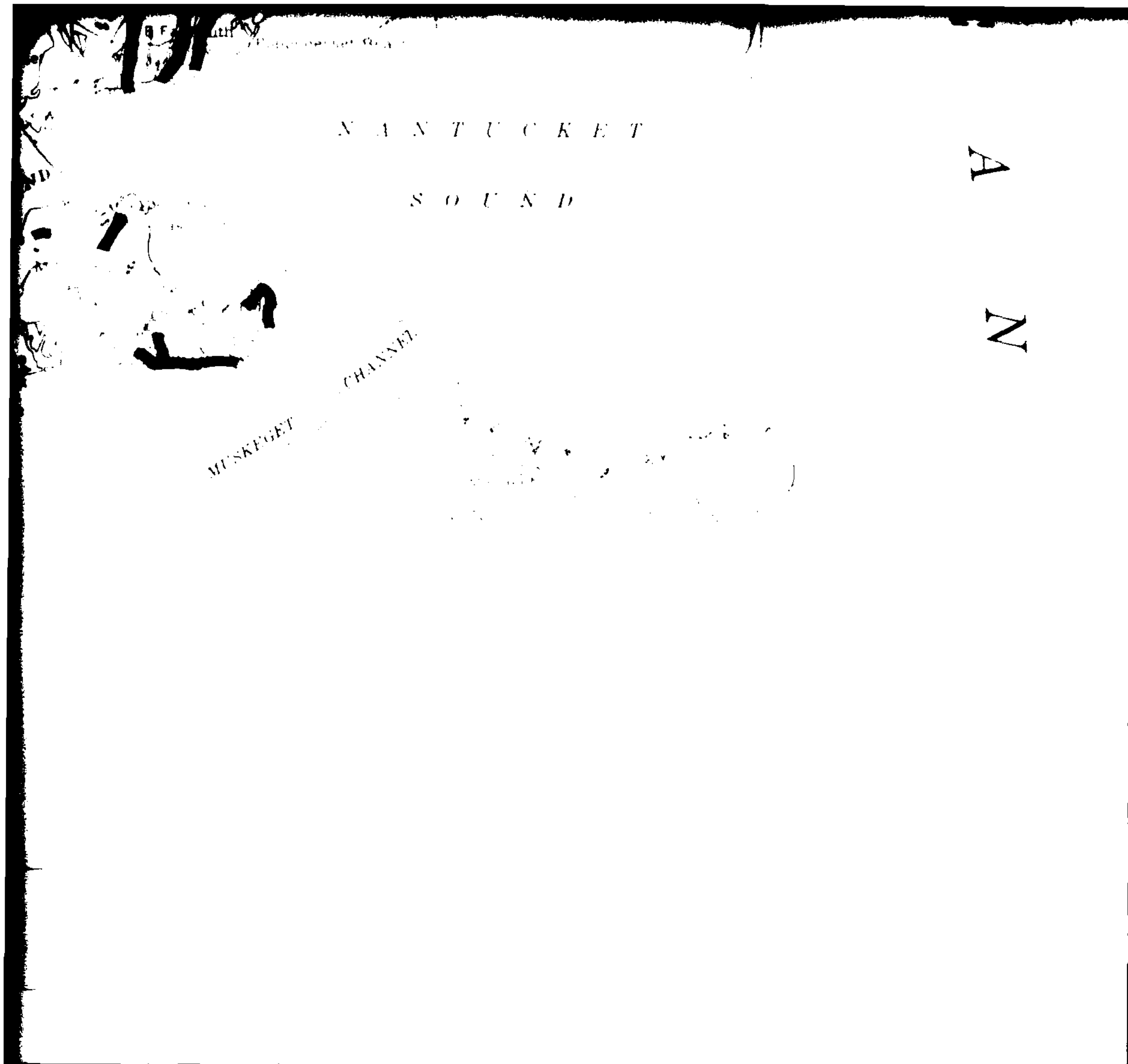
River

10

North



Hydropower Program
New England River Basins Commission

September, 1981

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Miles

North

Scale: 1:500,000
1 inch equals approximately 8 miles.

Source: U.S.G.S., 1975


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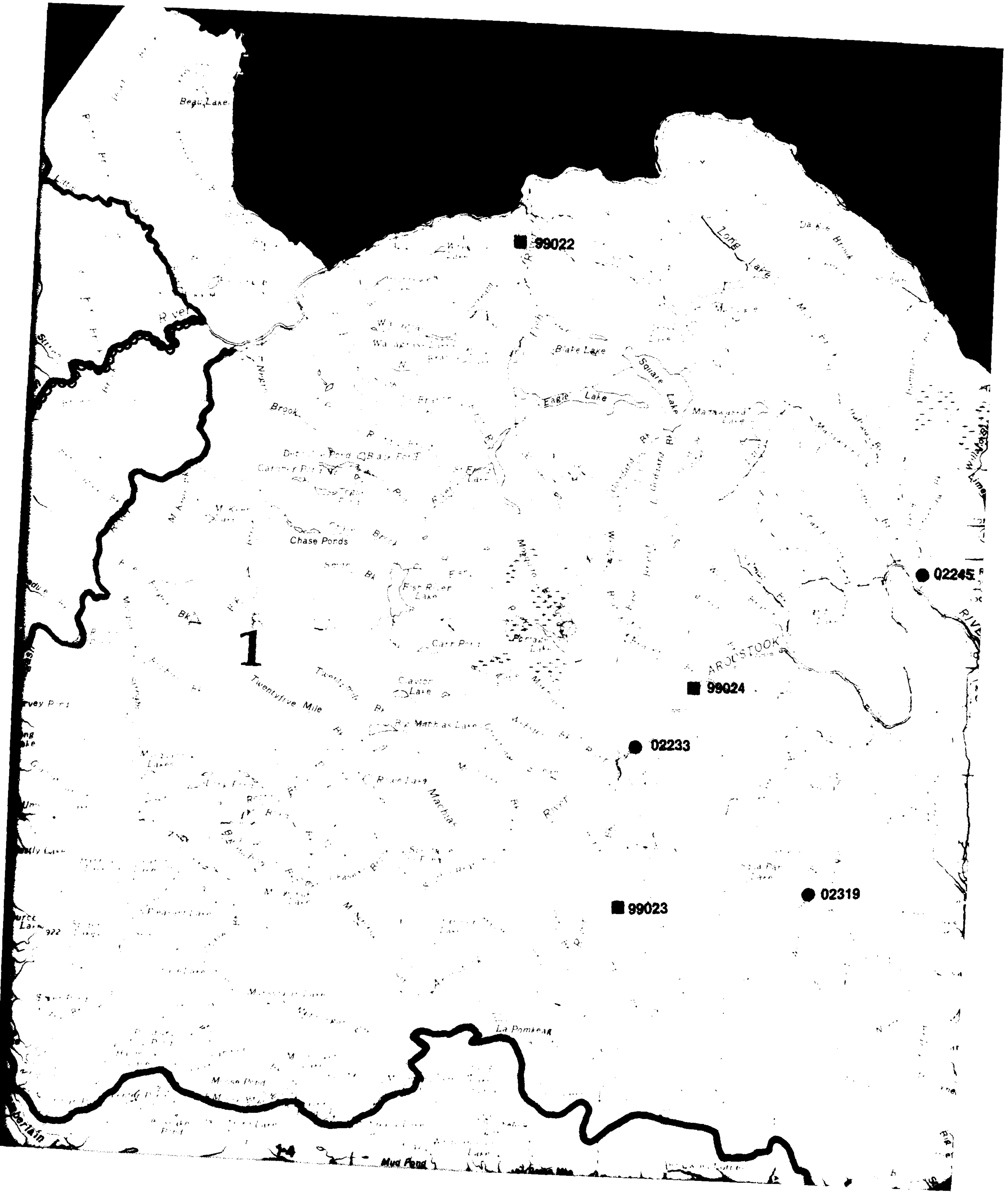

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Long Lake
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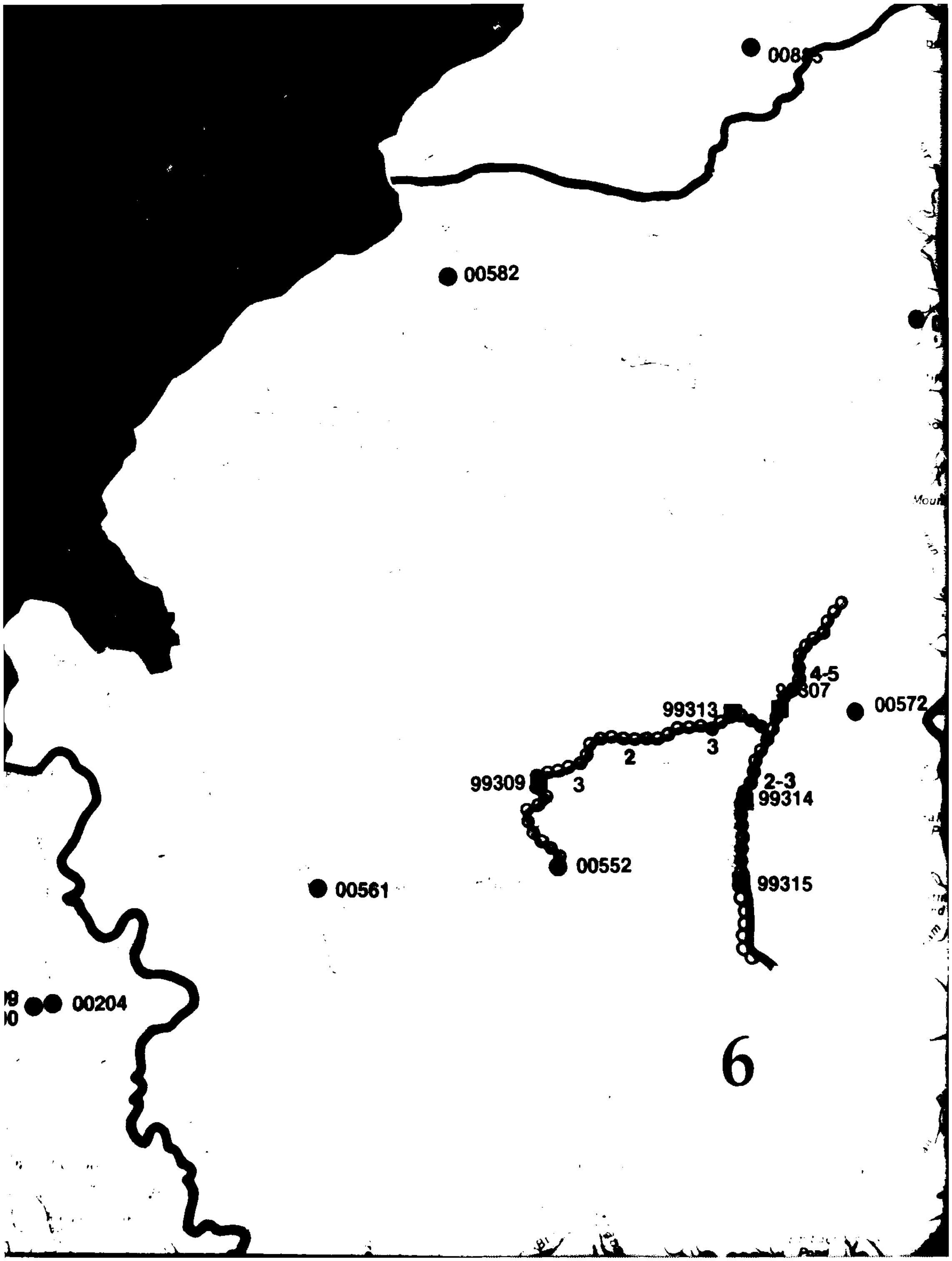
Carr Pond
Twentyfive Mile
Big Machias Lake
Machias
River
AROOSTOOK
La Pomkeag
Mud Pond
Brook

13



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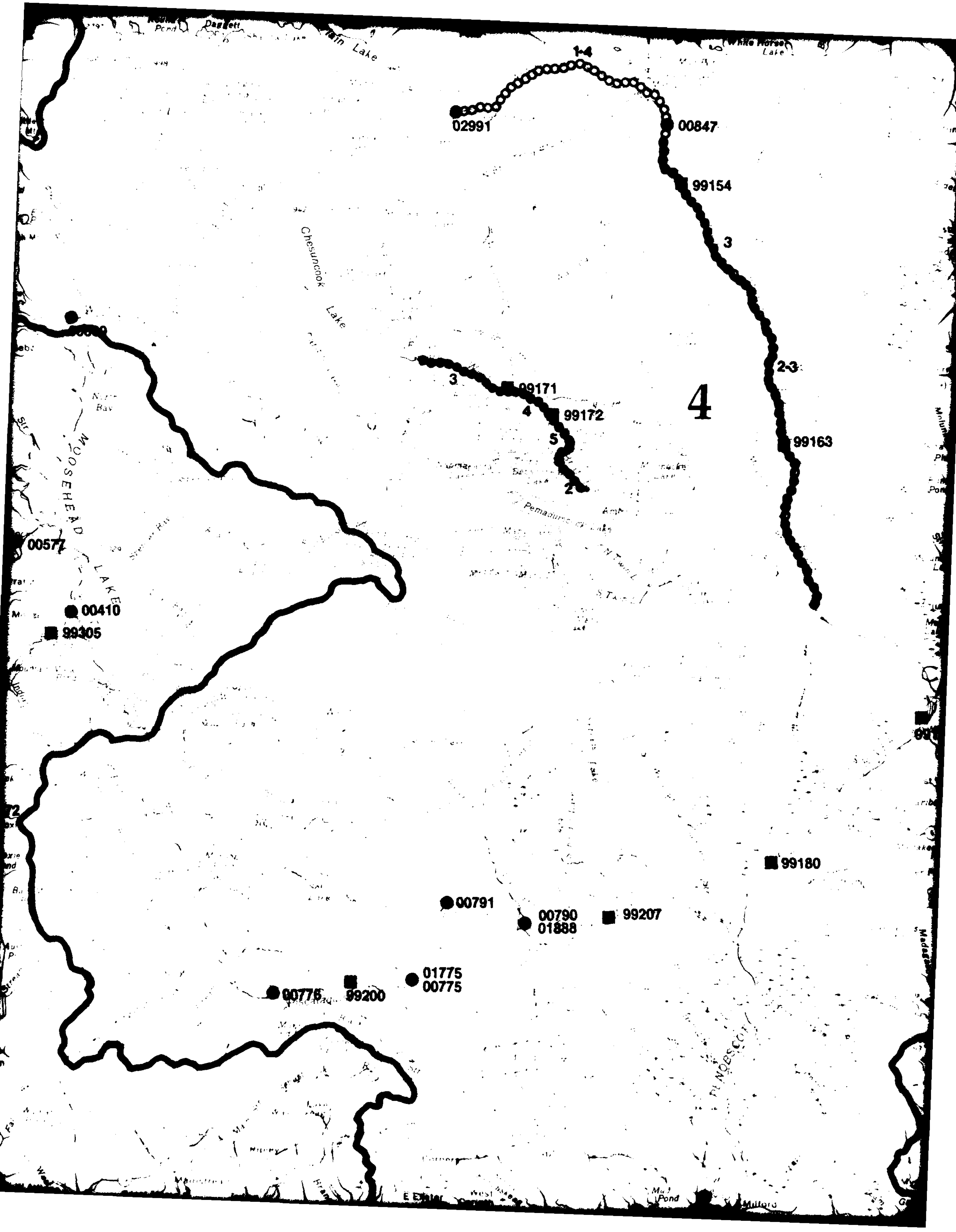

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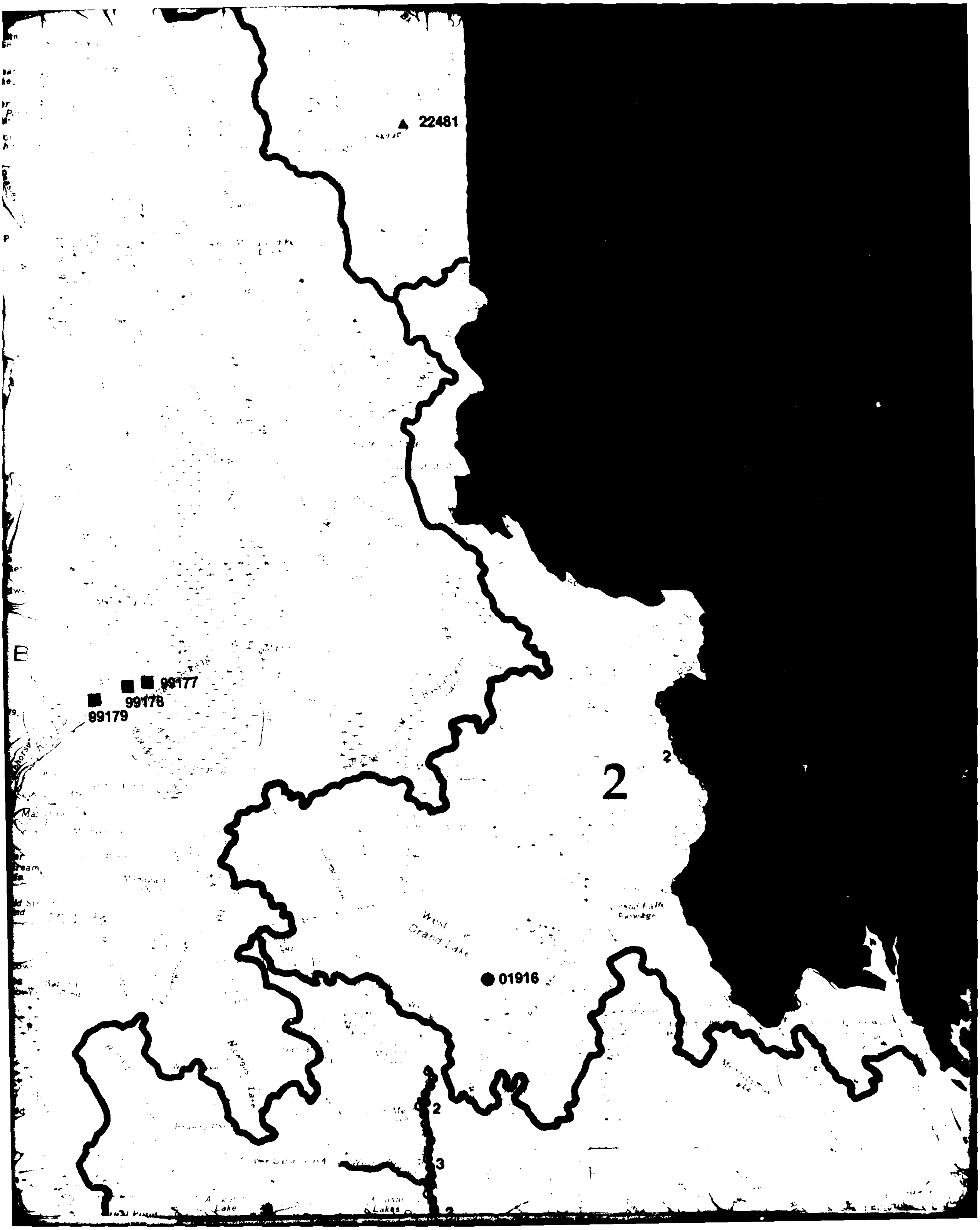
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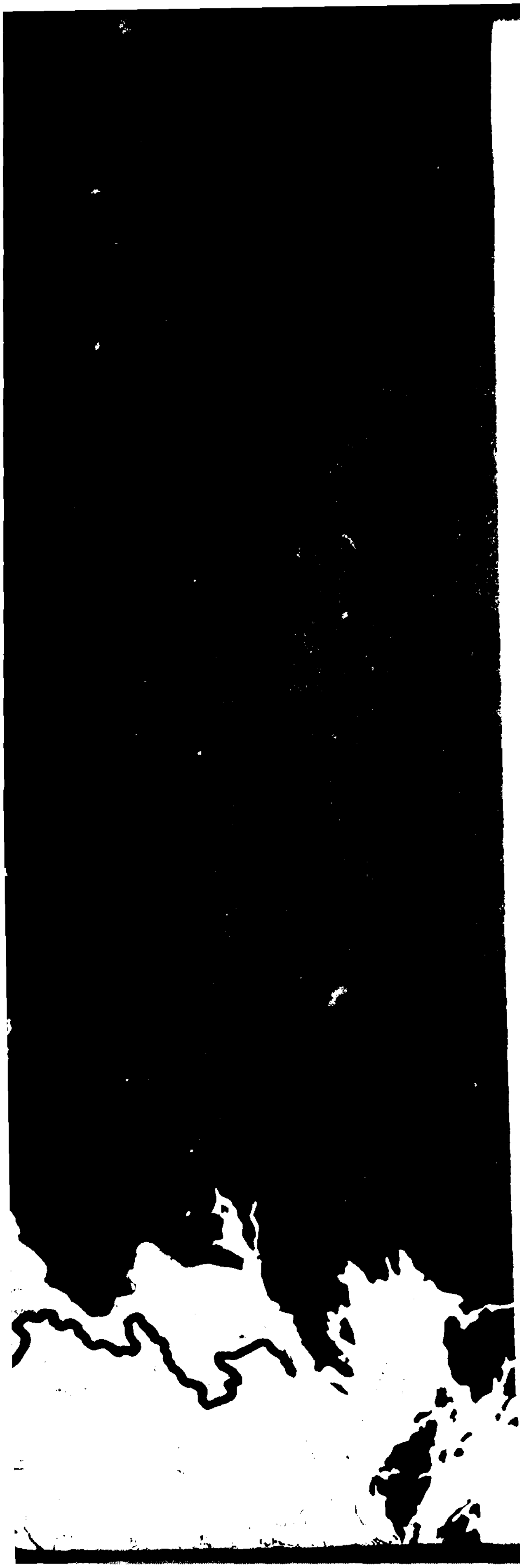

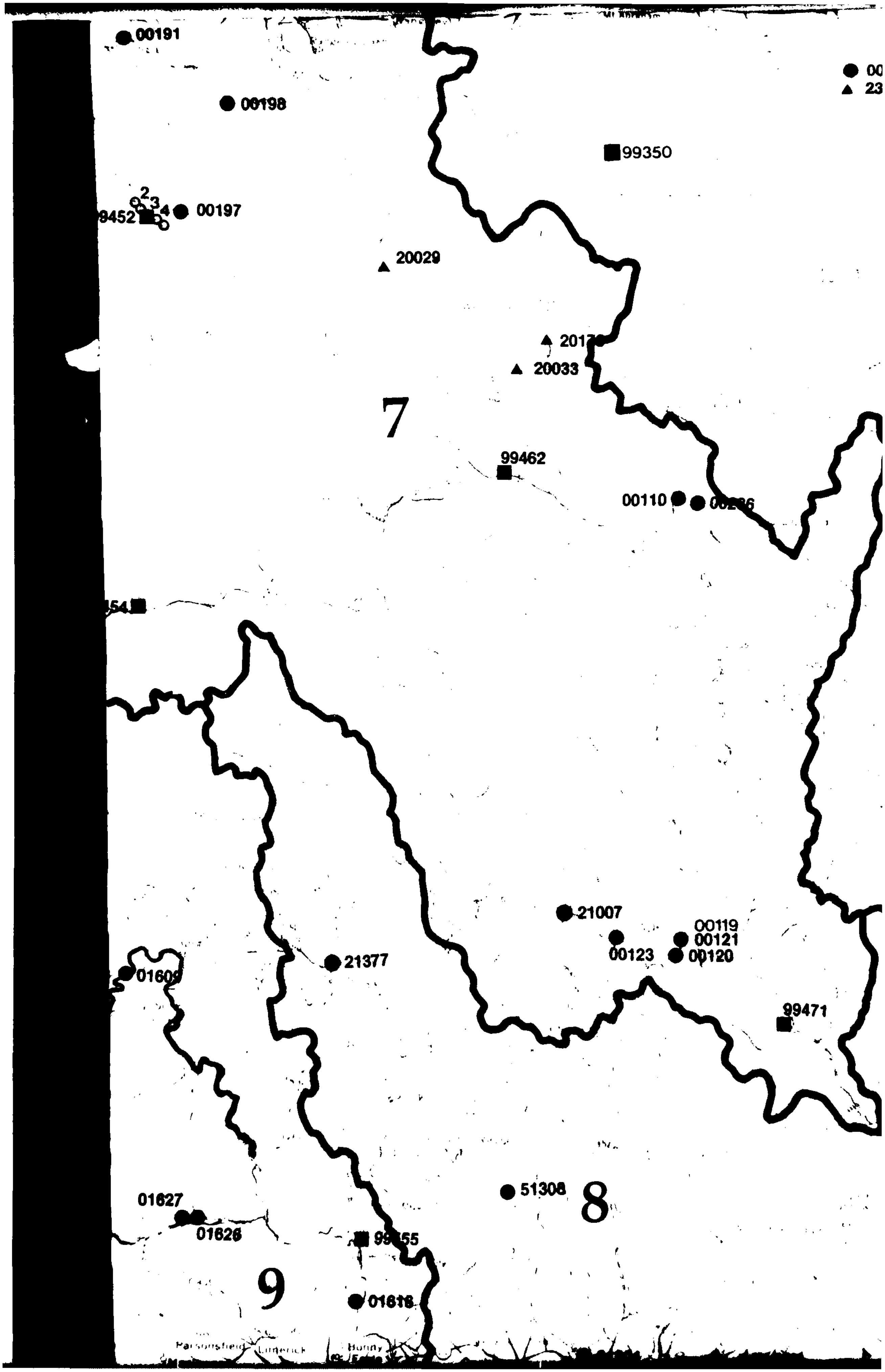
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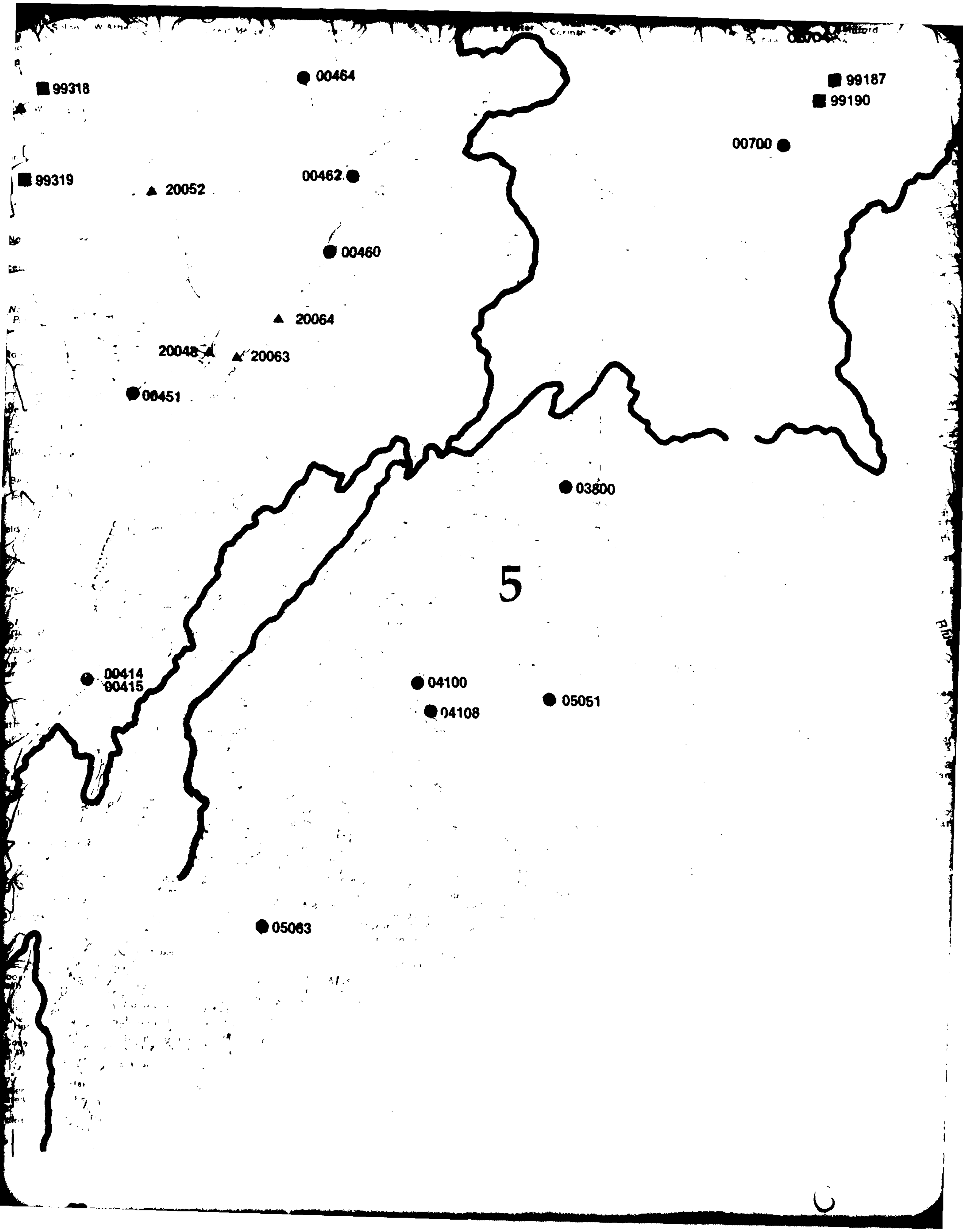
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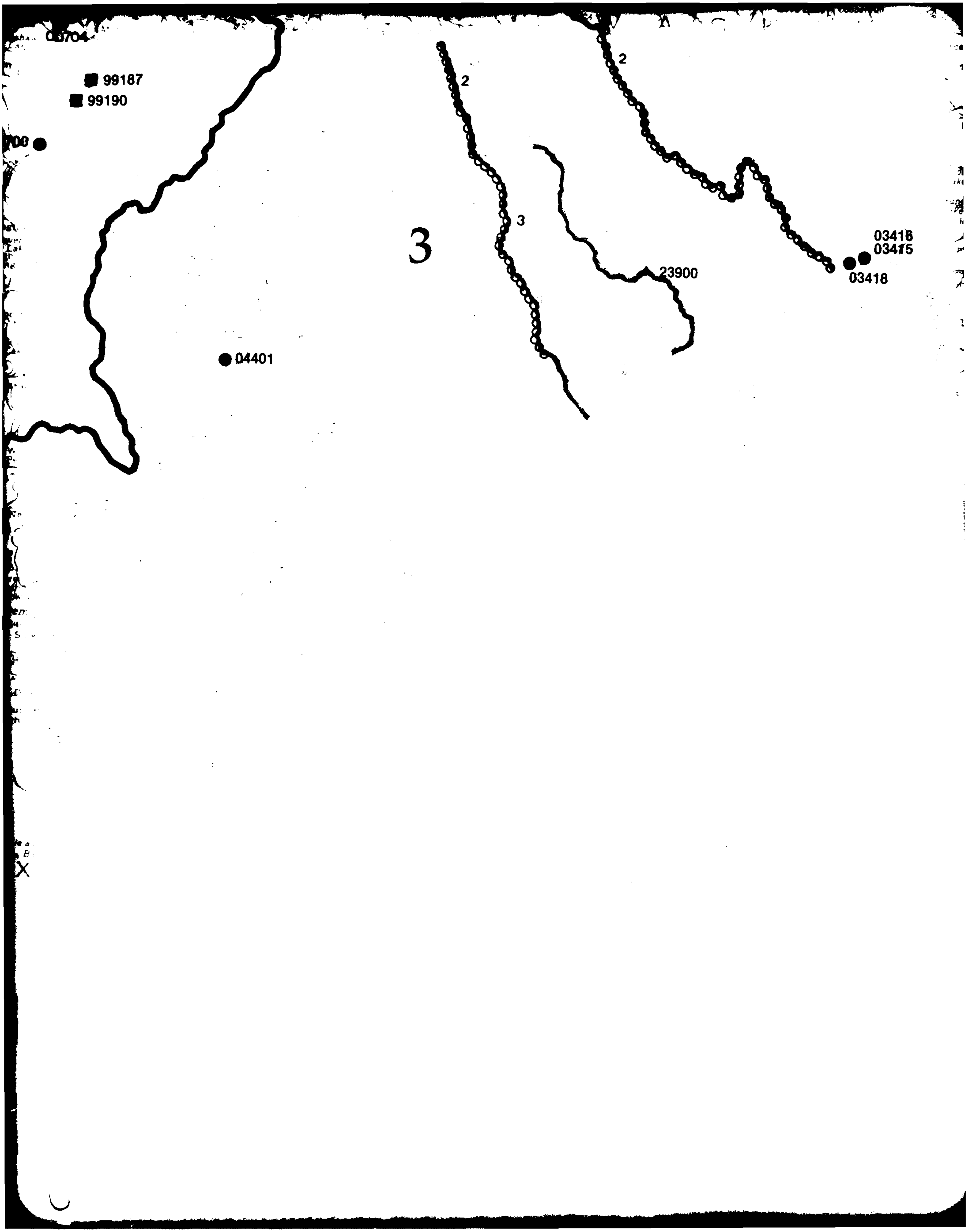

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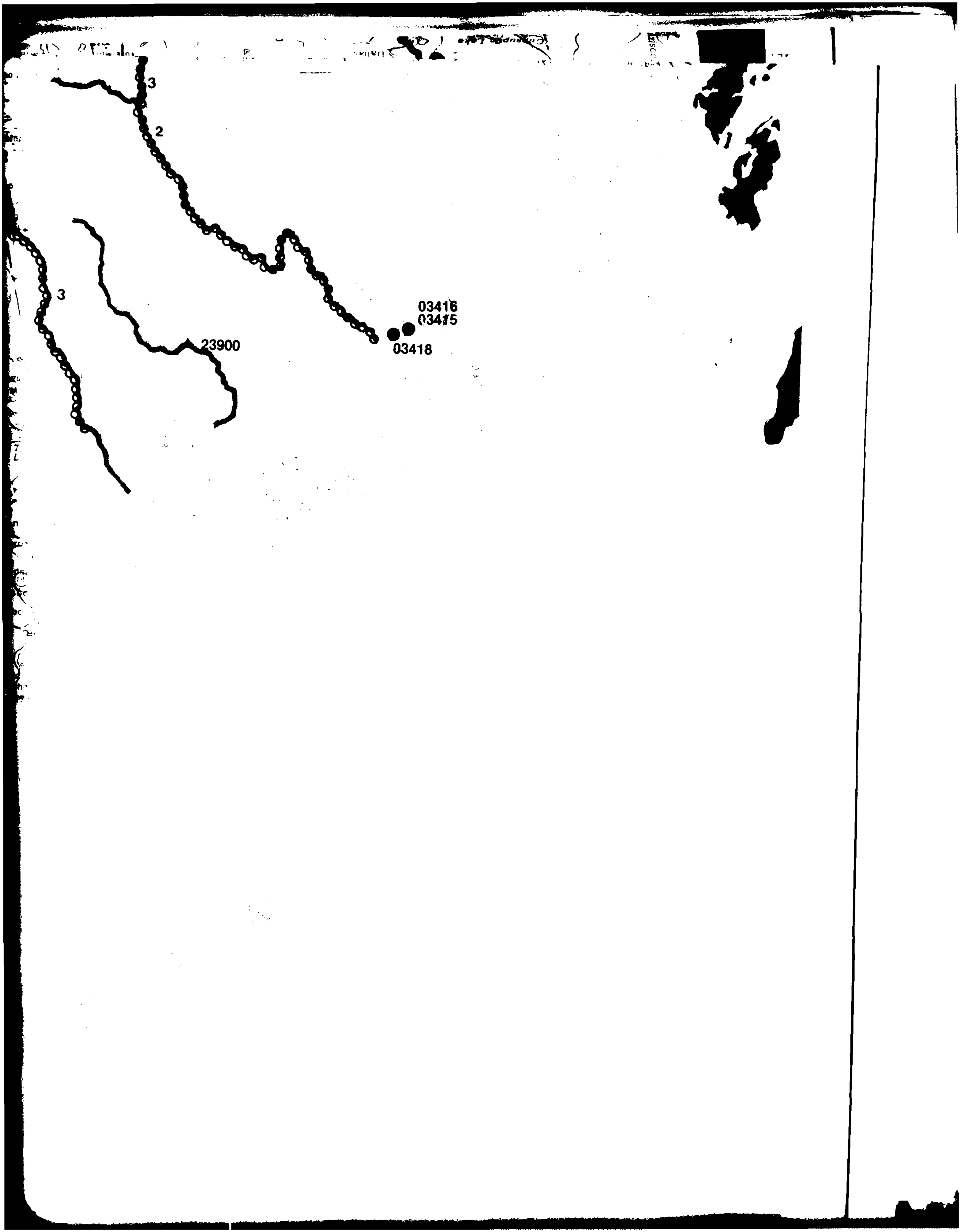

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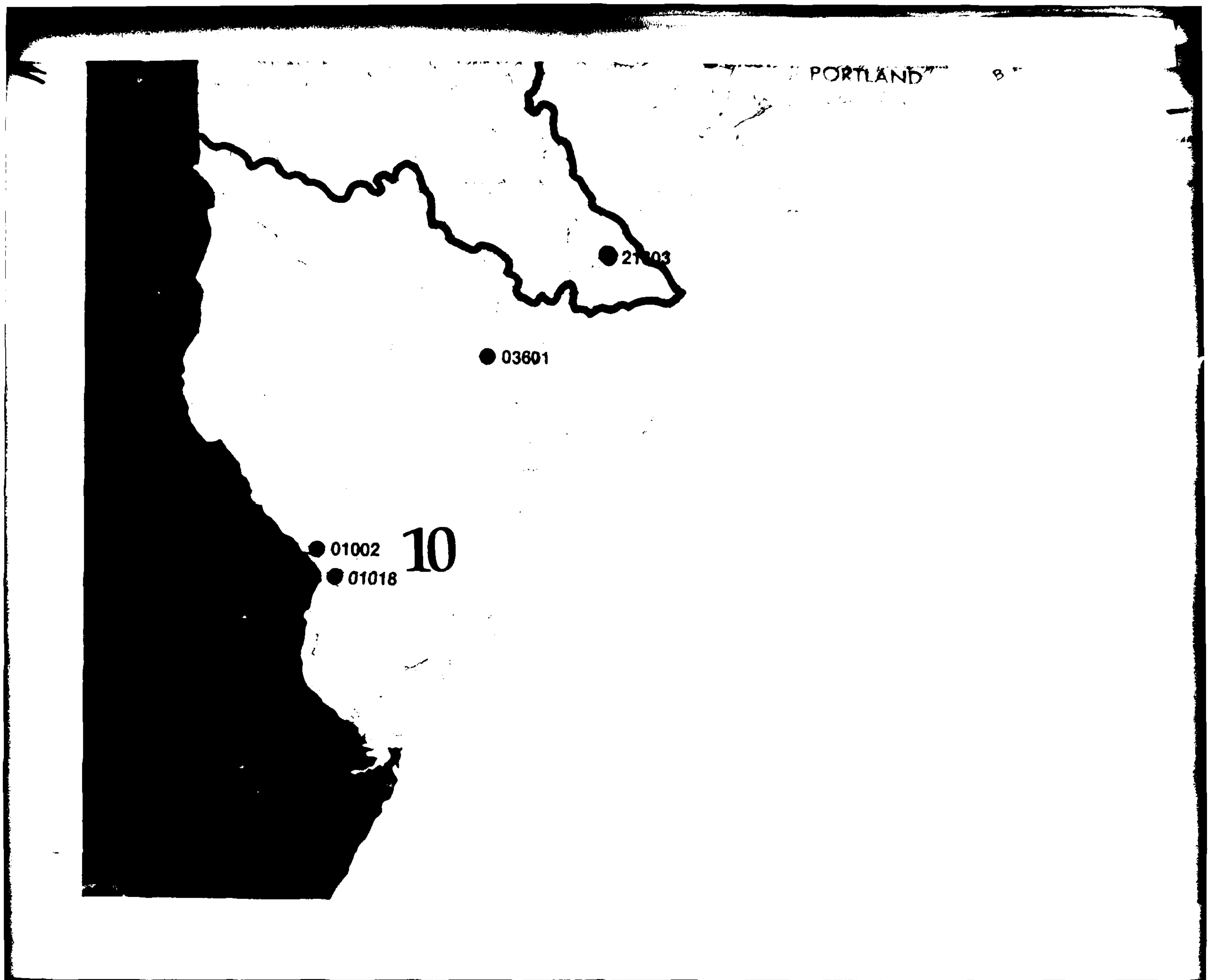

Potential Hydropower Sites:

- ●Existing dam
- ▲Breached dam
- ■Undeveloped site

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19. **Connecticut River Basin**

1 Recreational and Scenic

Scenic segment:
Aesthetic, historic, geologic or ecologic value

Recreational segment:
Flatwater canoe
White water
Potential difficulty of whitewater:
2 Easy **3** Medium **4** Difficult **5** Very Difficult

Data Source:
Appendix D of ***Water, Watts, and Wilds; Hydropower and Competing Uses in New England***

C

Scenic Rivers

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September, 1981

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Miles

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Scale: 1:500,000

1 inch equals approximately 8 miles

Source: U.S.G.S., 1975

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●Existing dam
▲Breached dam
■Undeveloped site

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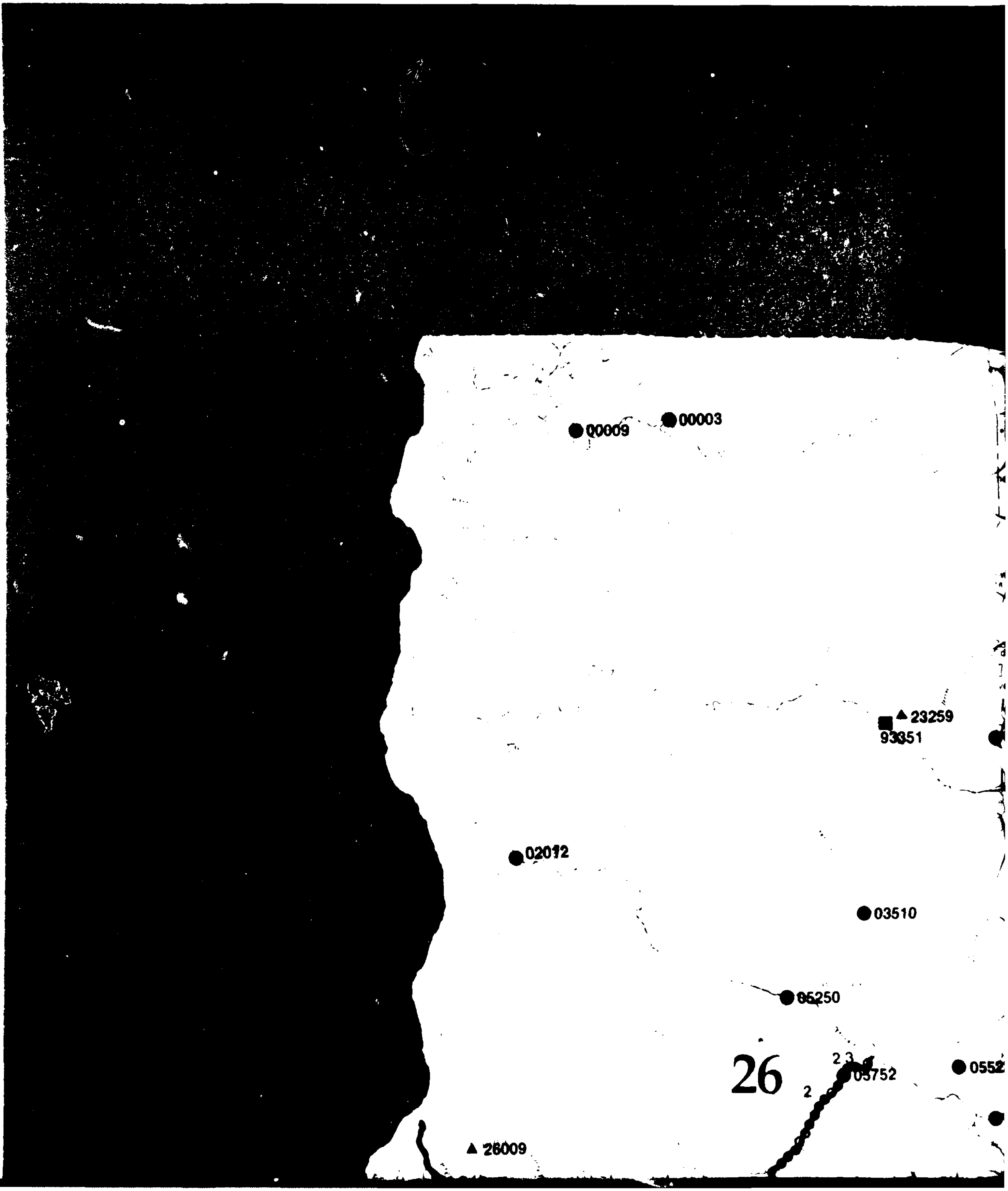
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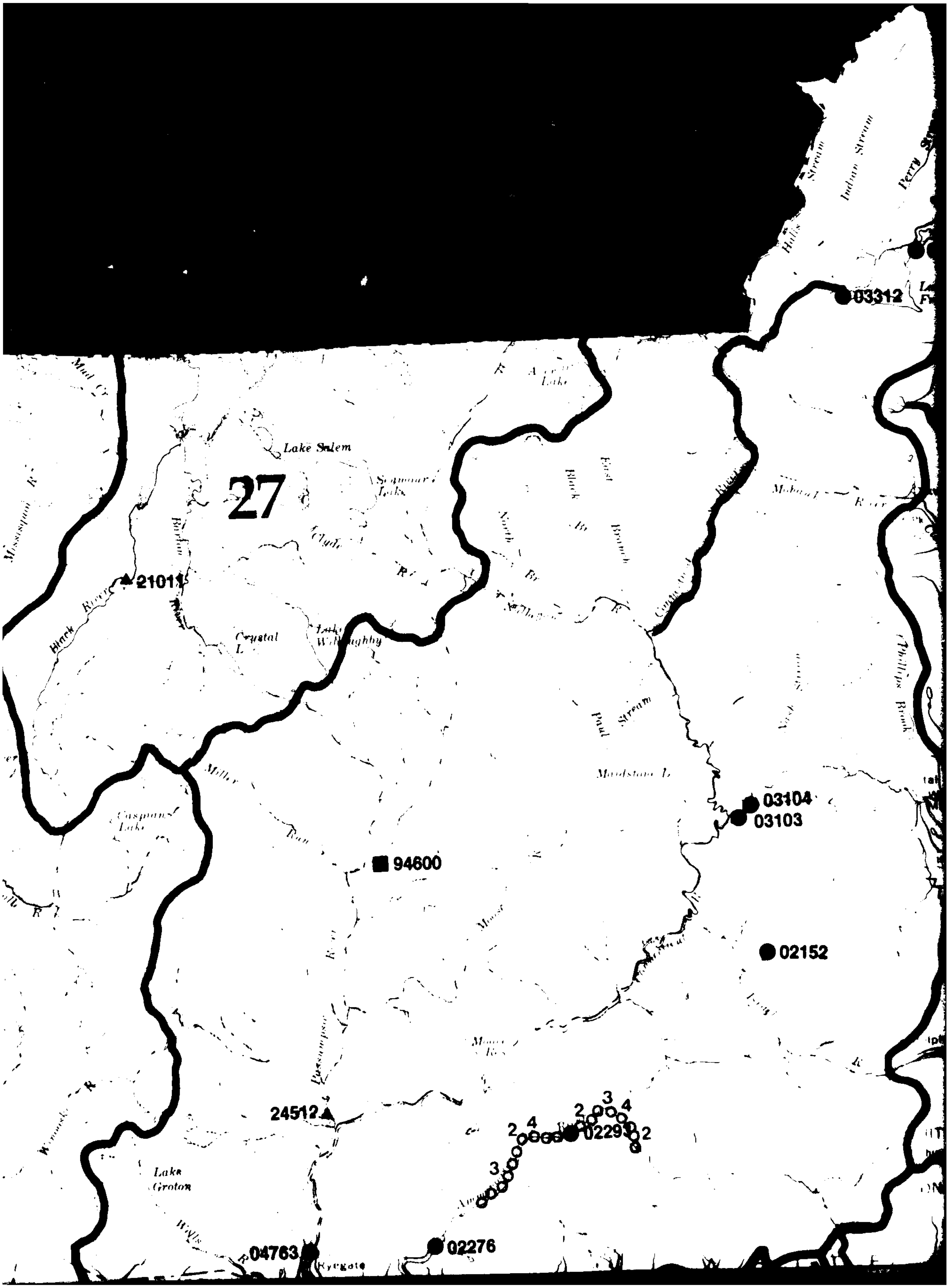

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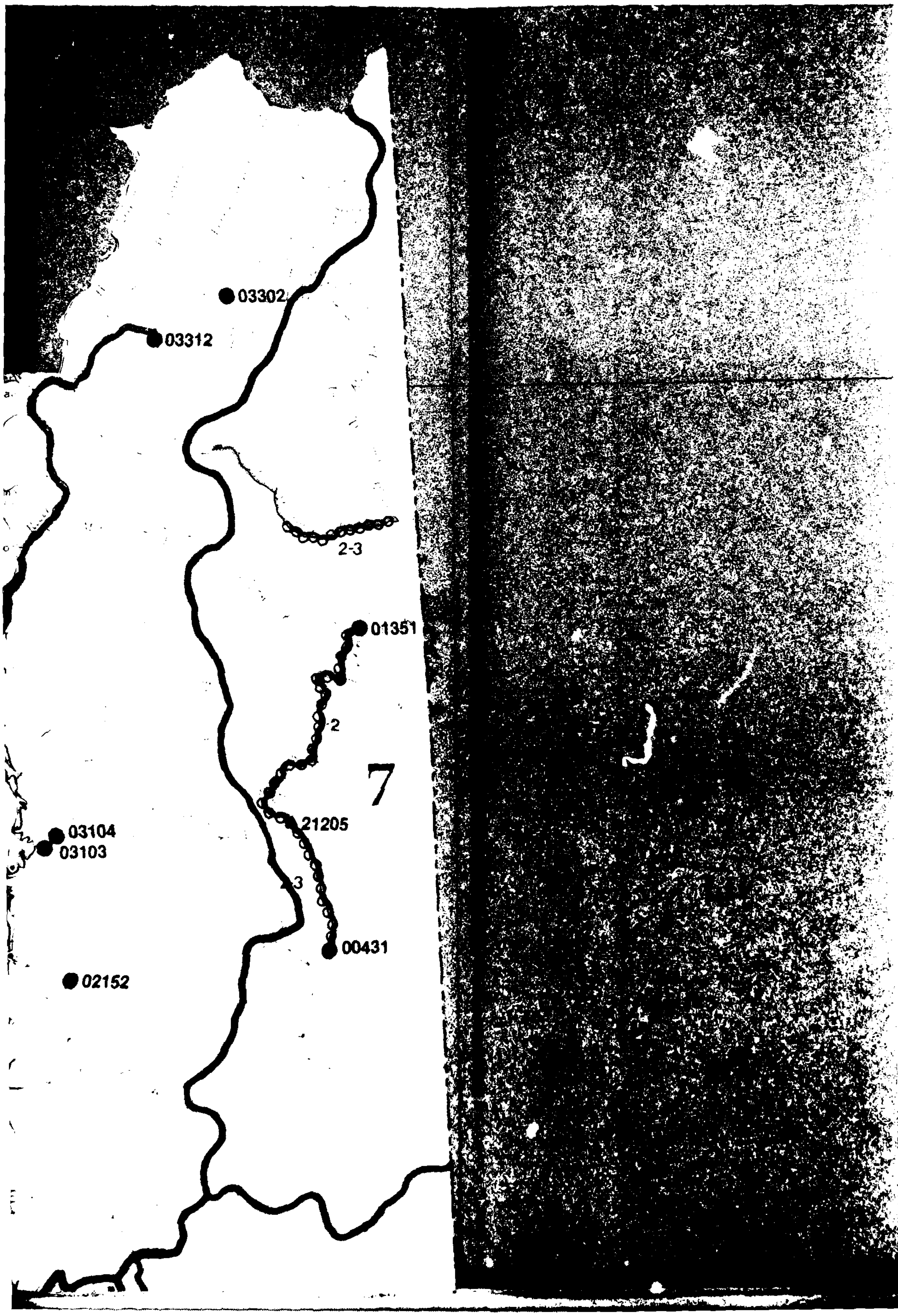

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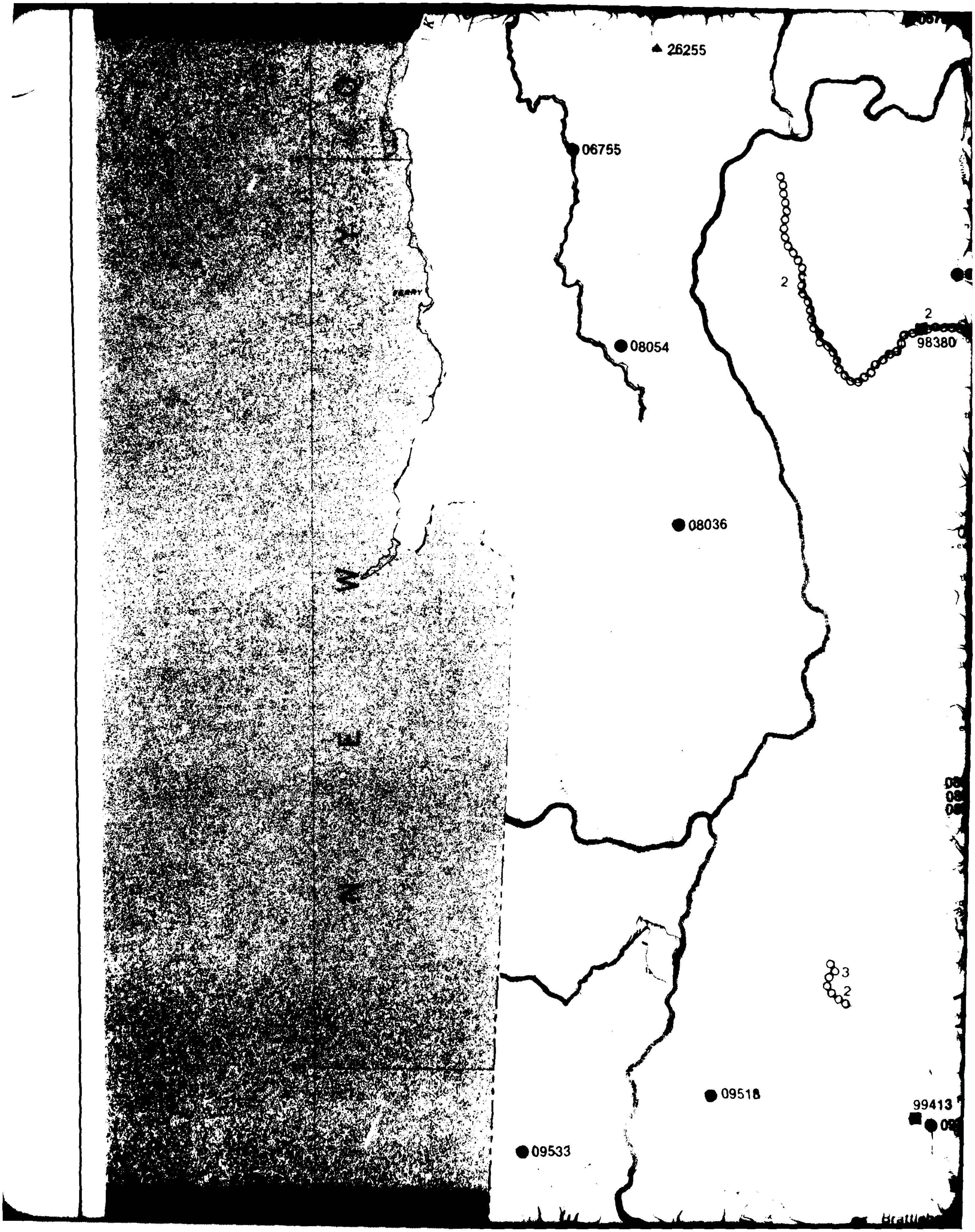
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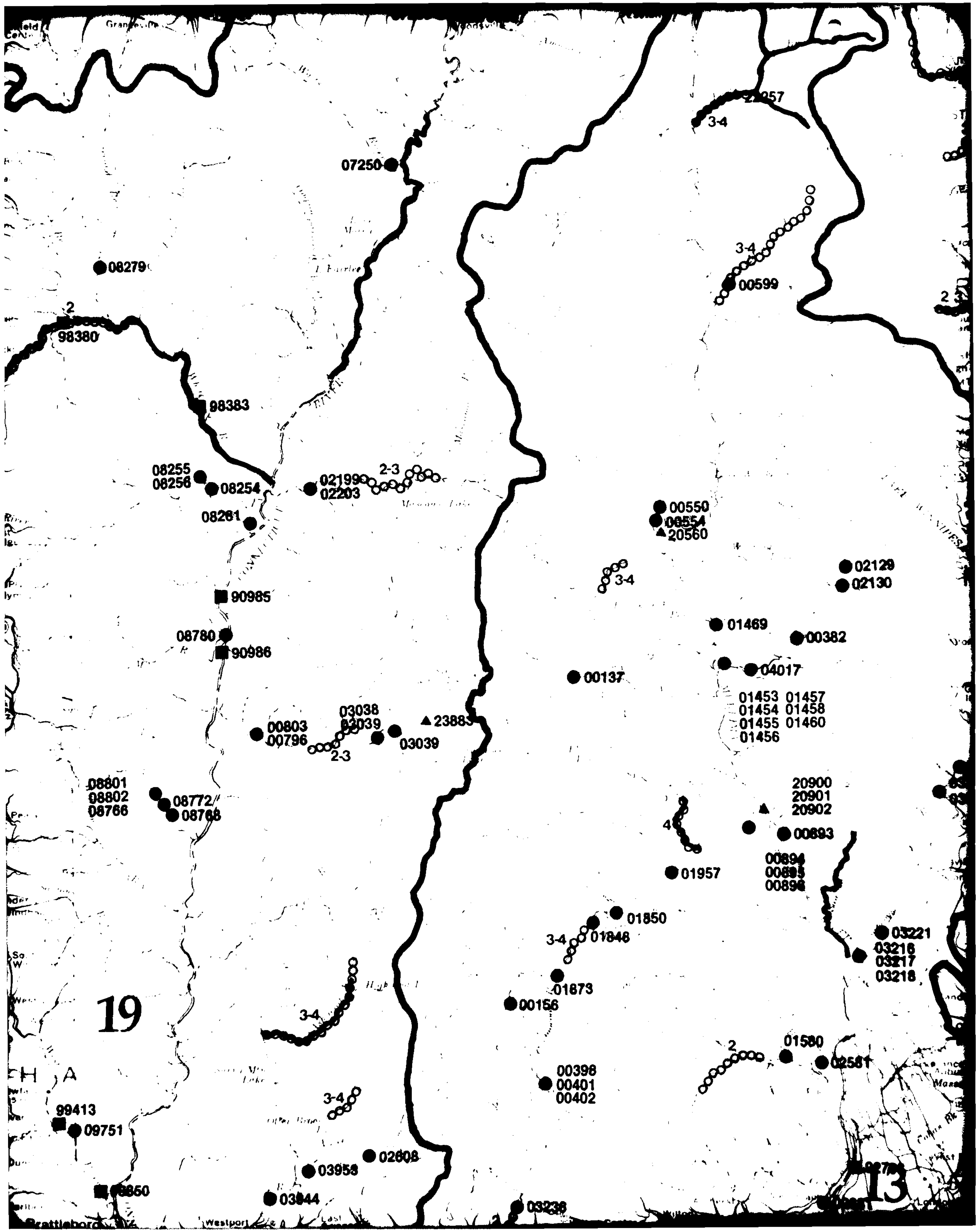

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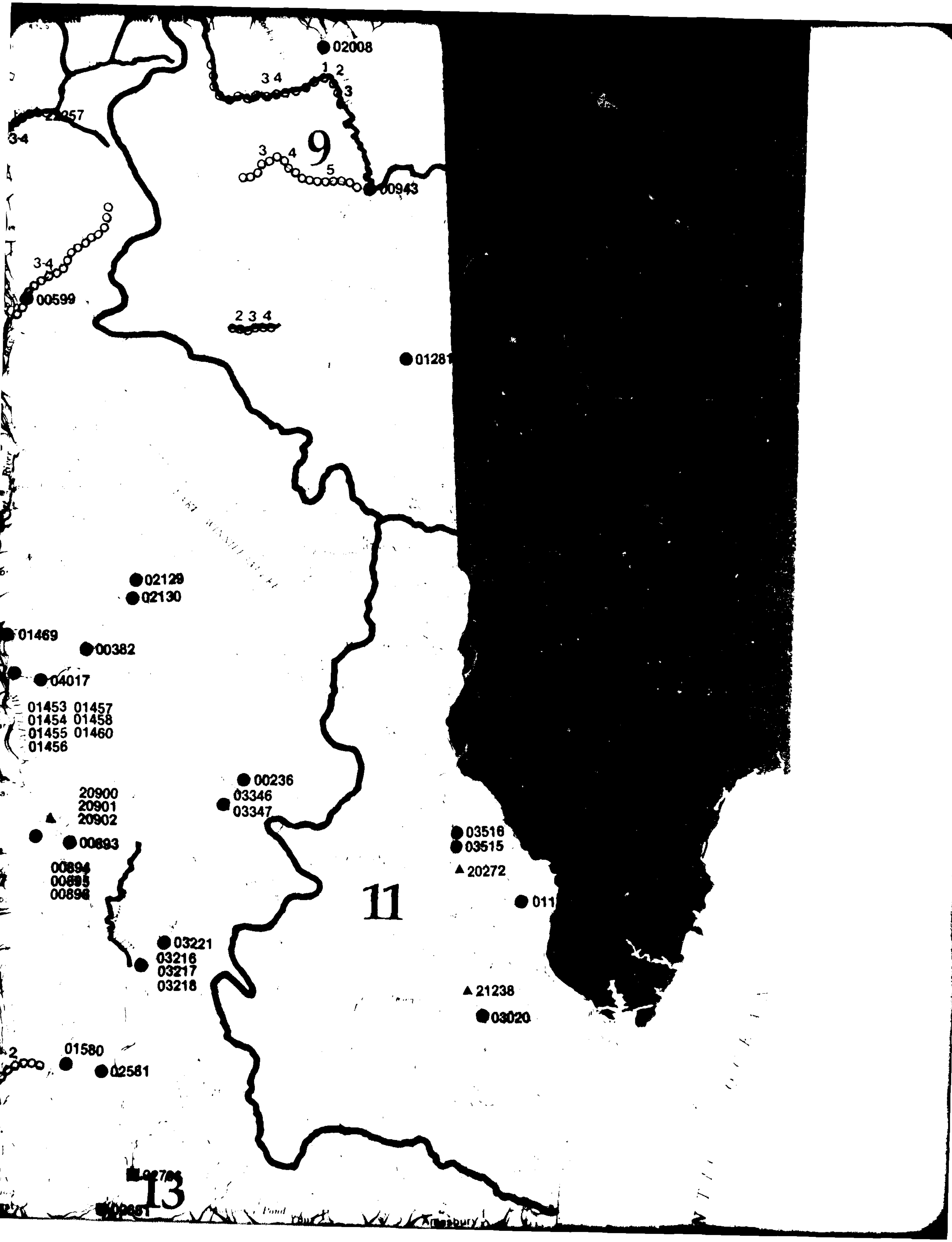

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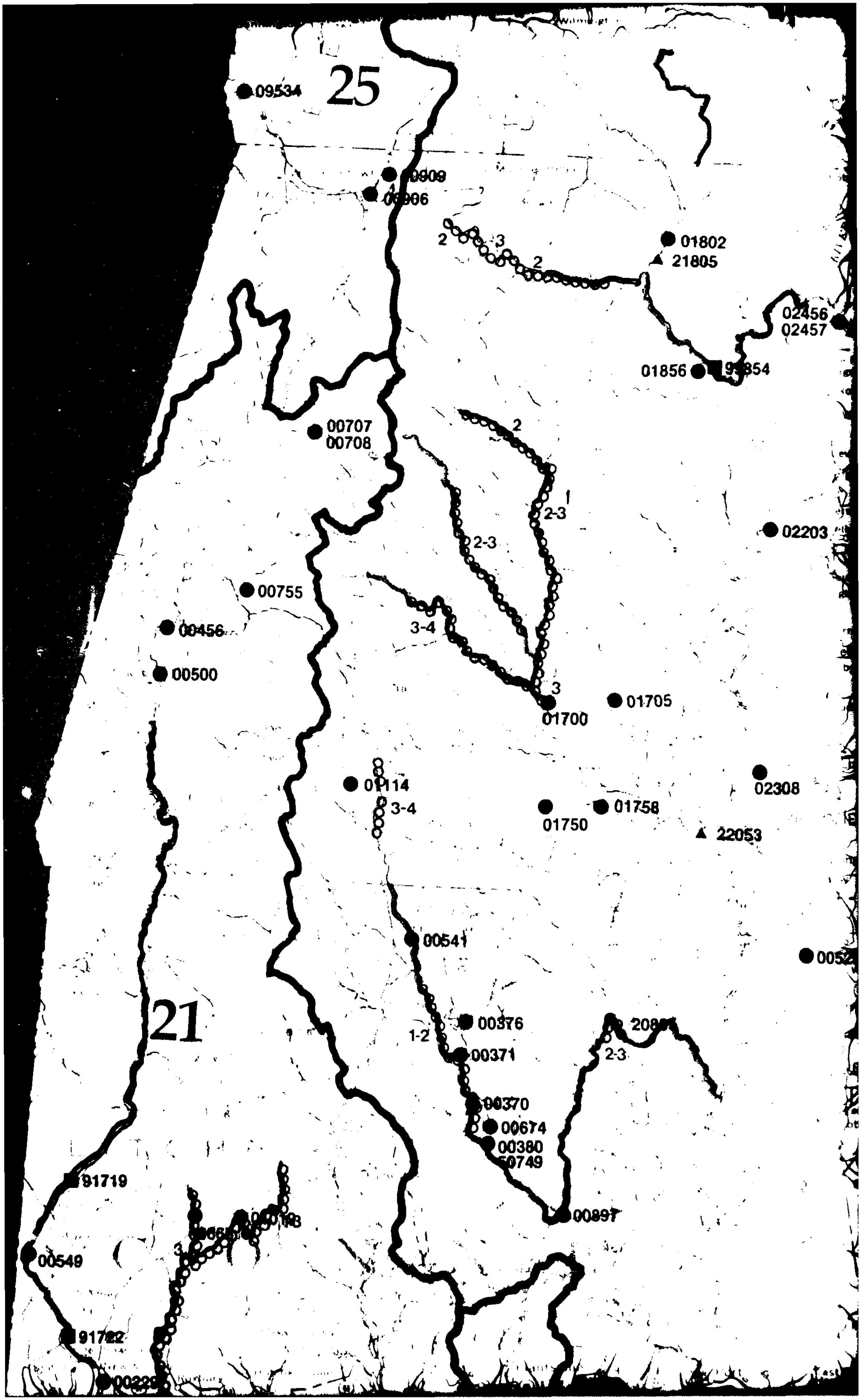

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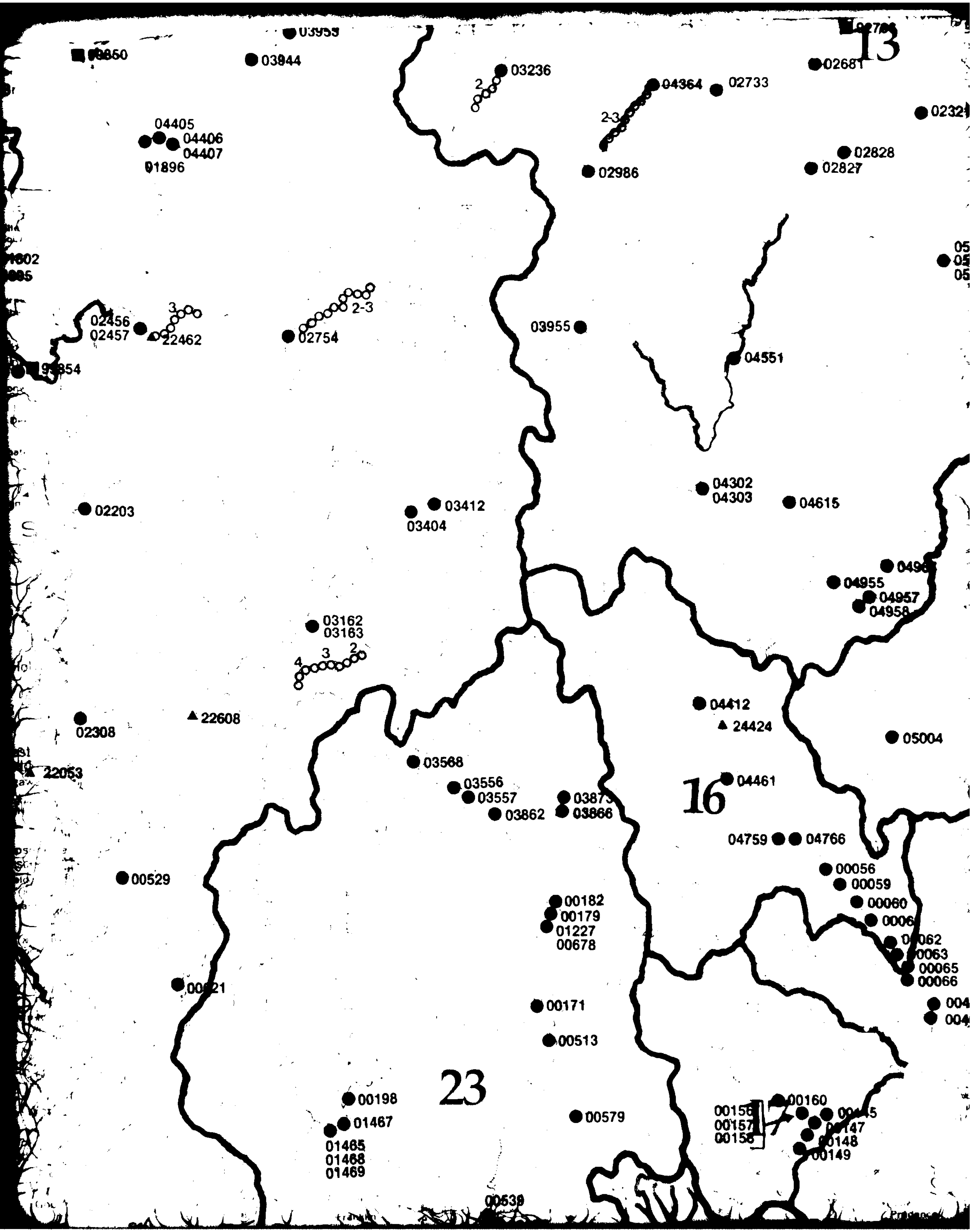
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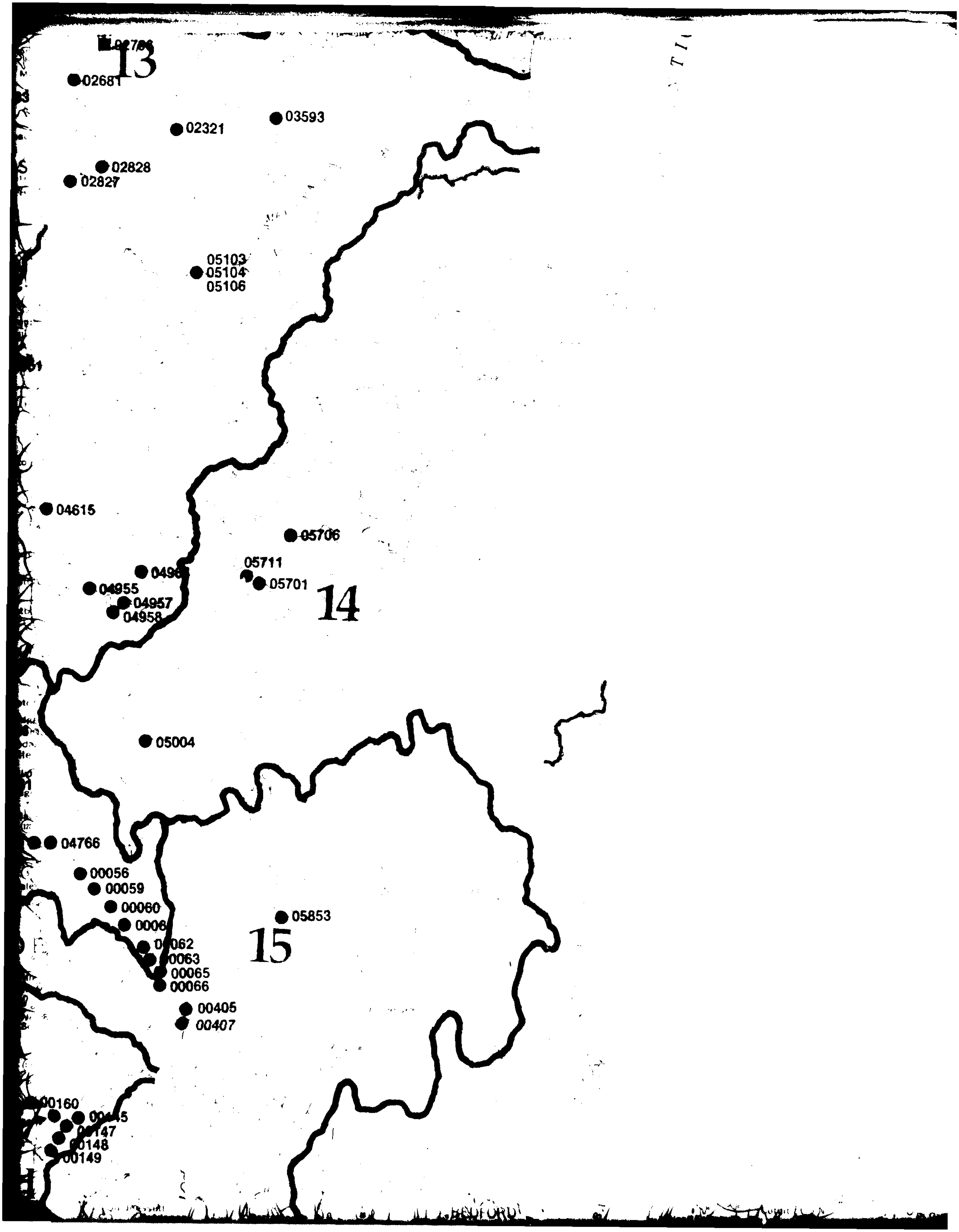
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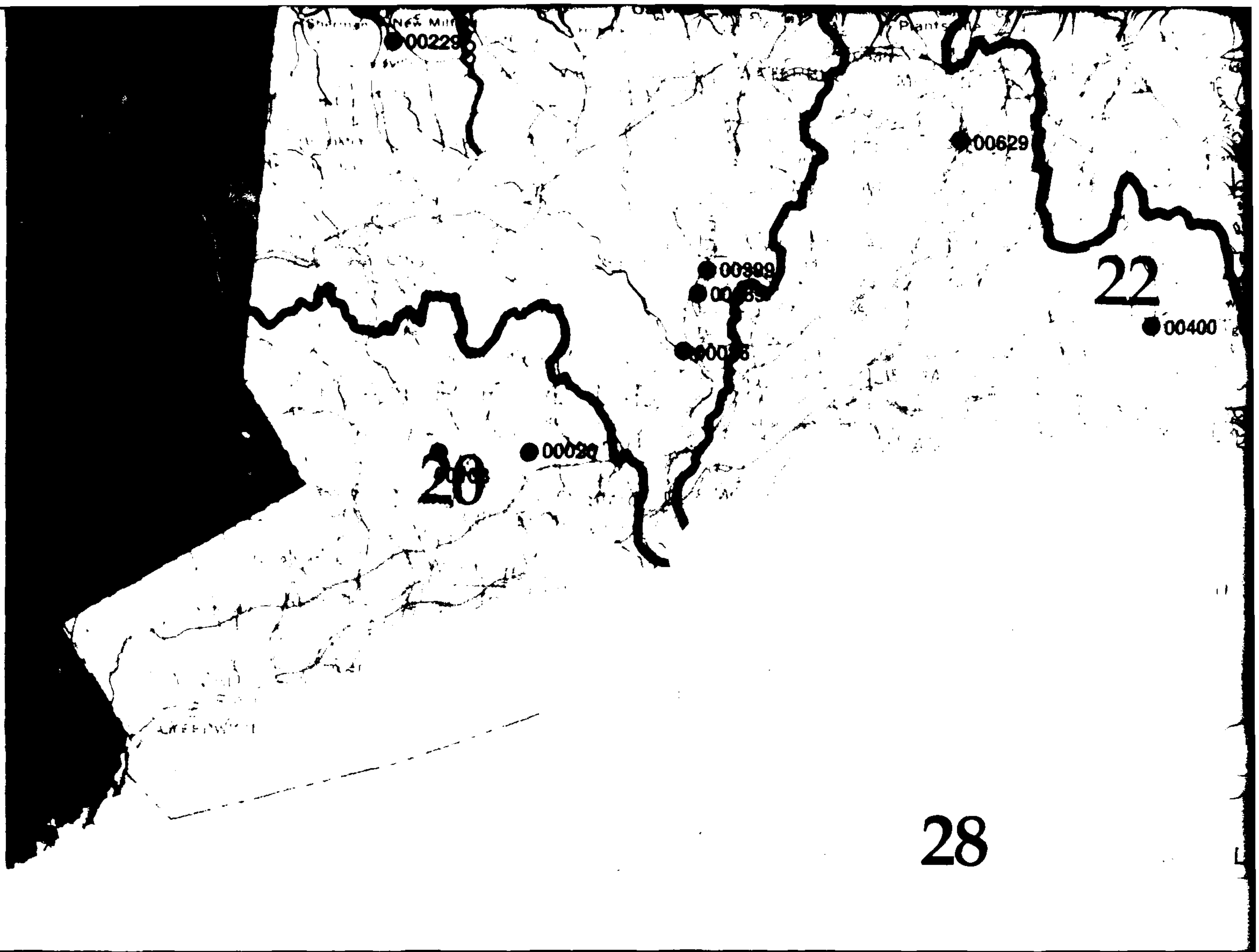

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12. New Hampshire Coastal Rivers
13. Merrimack River Basin
14. Massachusetts Coastal Rivers
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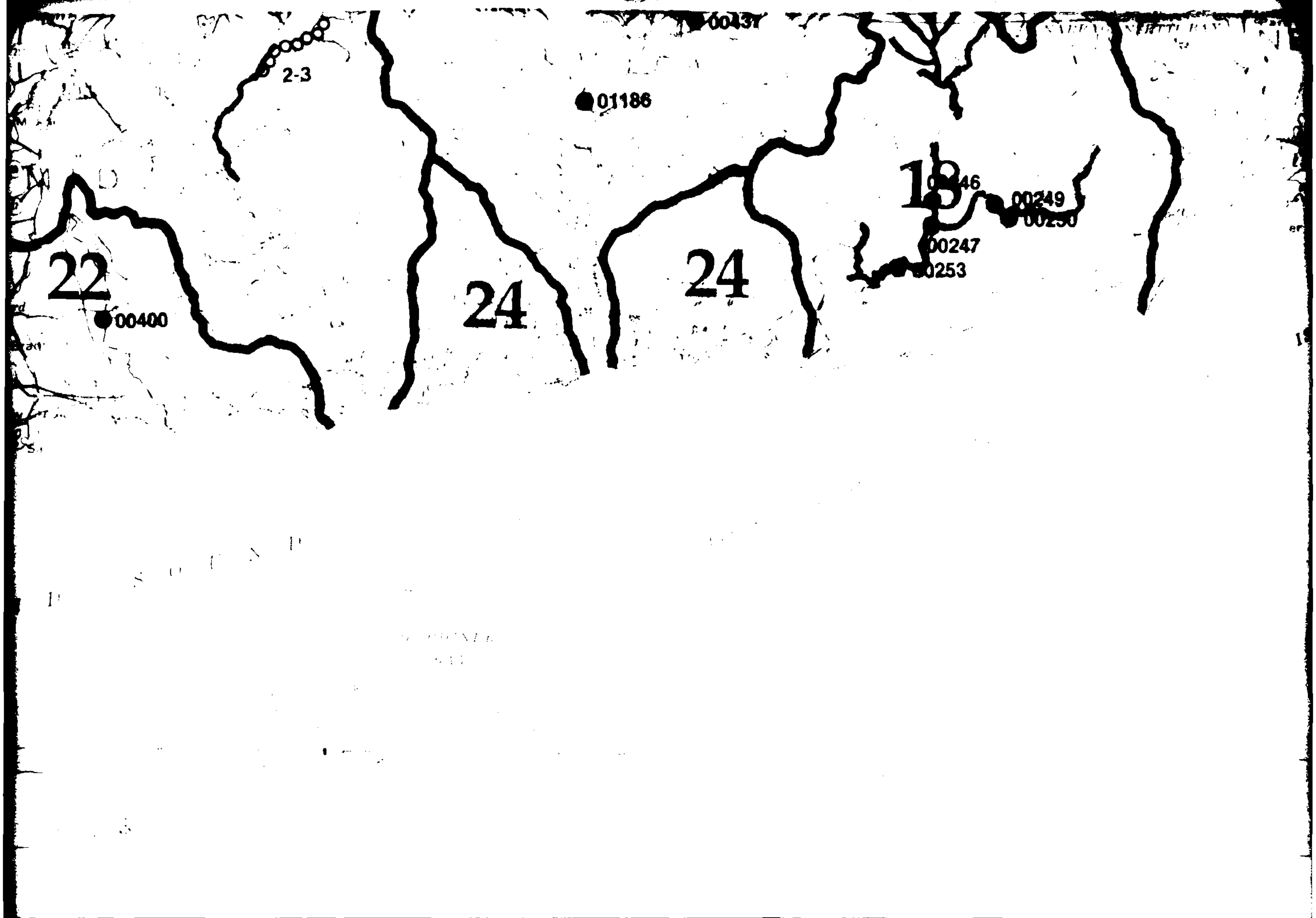
16. Blackstone River Basin
17. Pawtuxet River Basin
18. Pawcatuck River Rhode Island Coastal Drainage Basins
19. Connecticut River Basin
20. Connecticut Western Coastal Rivers
21. Housatonic River Basin
22. Connecticut Central Coastal Rivers
23. Thames River Basin
24. Connecticut Eastern Coastal Rivers
25. Hudson River Basin (Hoosic & Batten Kill Rivers)
26. Lake Champlain Drainage Basin
27. St. Francis River Basin
28. New York (Long Island) Coastal Drainage Basin

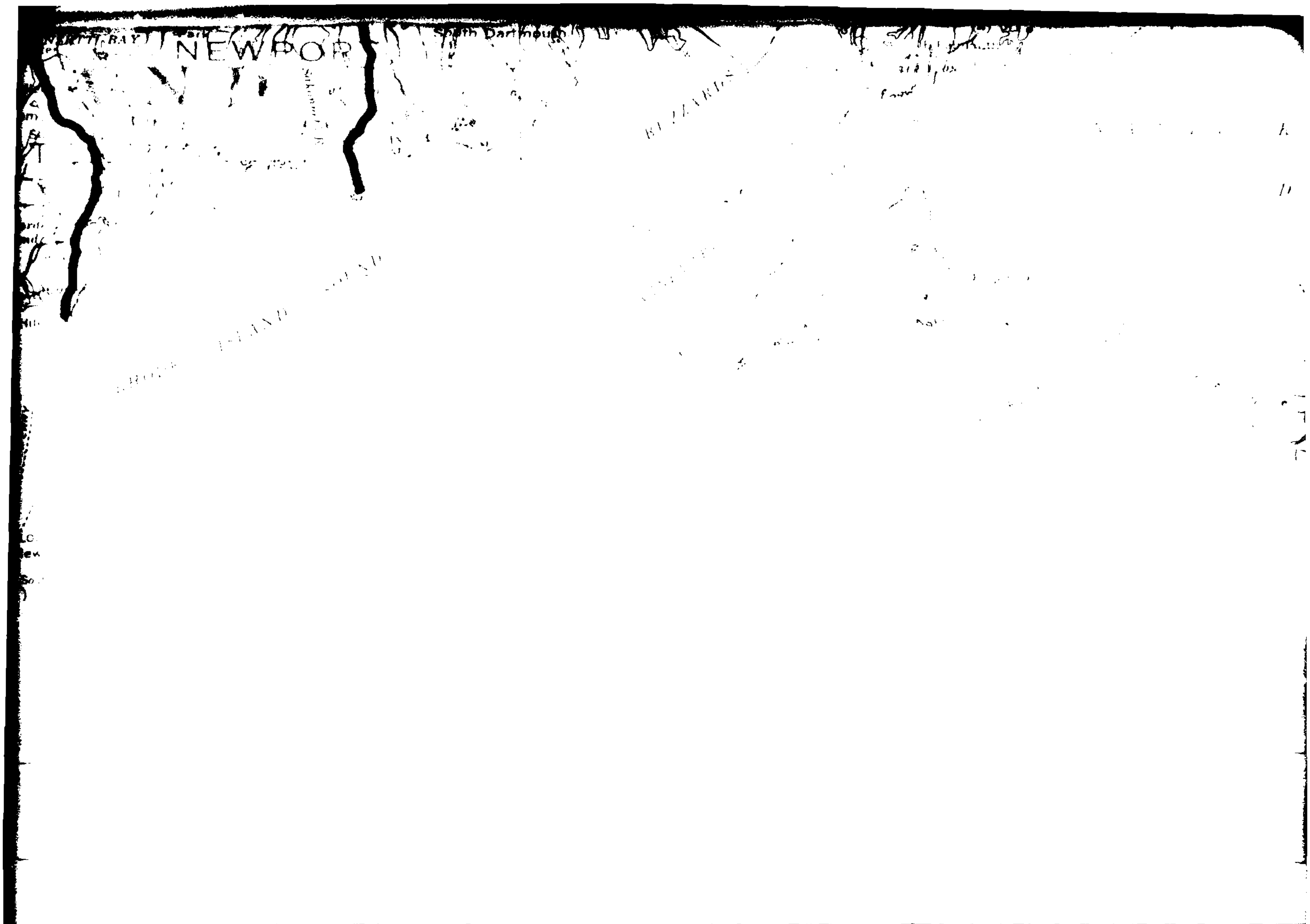


1 Recreational and Scen

Scenic segment:
Aesthetic, historic, geologic or ecologic value

Recreational segment:
Flatwater
White water
Potential difficulty of whitewater:
2 Easy **3** Medium **4** Difficult **5** Very Difficult

Data Source:
Appendix D of ***Water, Watts, and Wilds; Hydropower and Competing Uses in New England***



d Scenic Rivers

Hydro
New E
River B

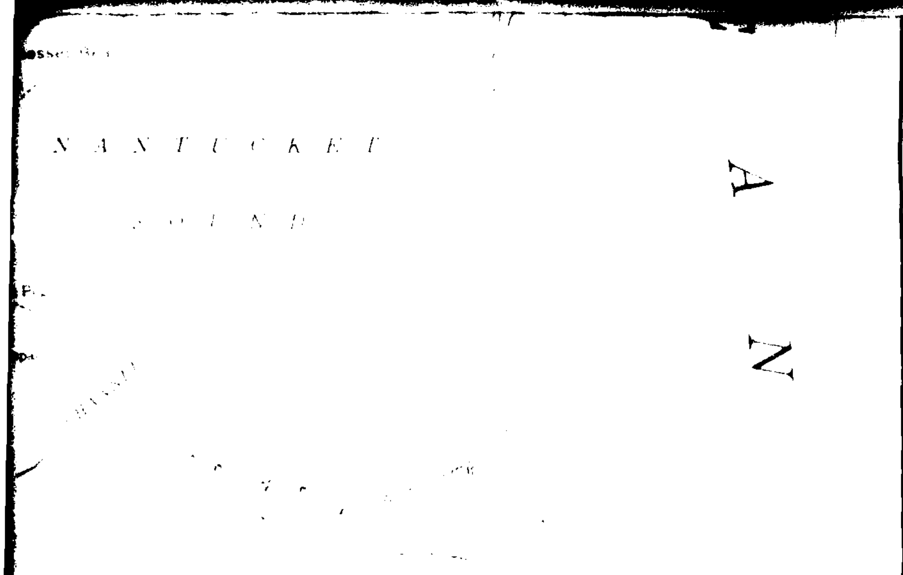
Se

10

North

S
1

S



Hydropower Program
New England River Basins Commission

September, 1981

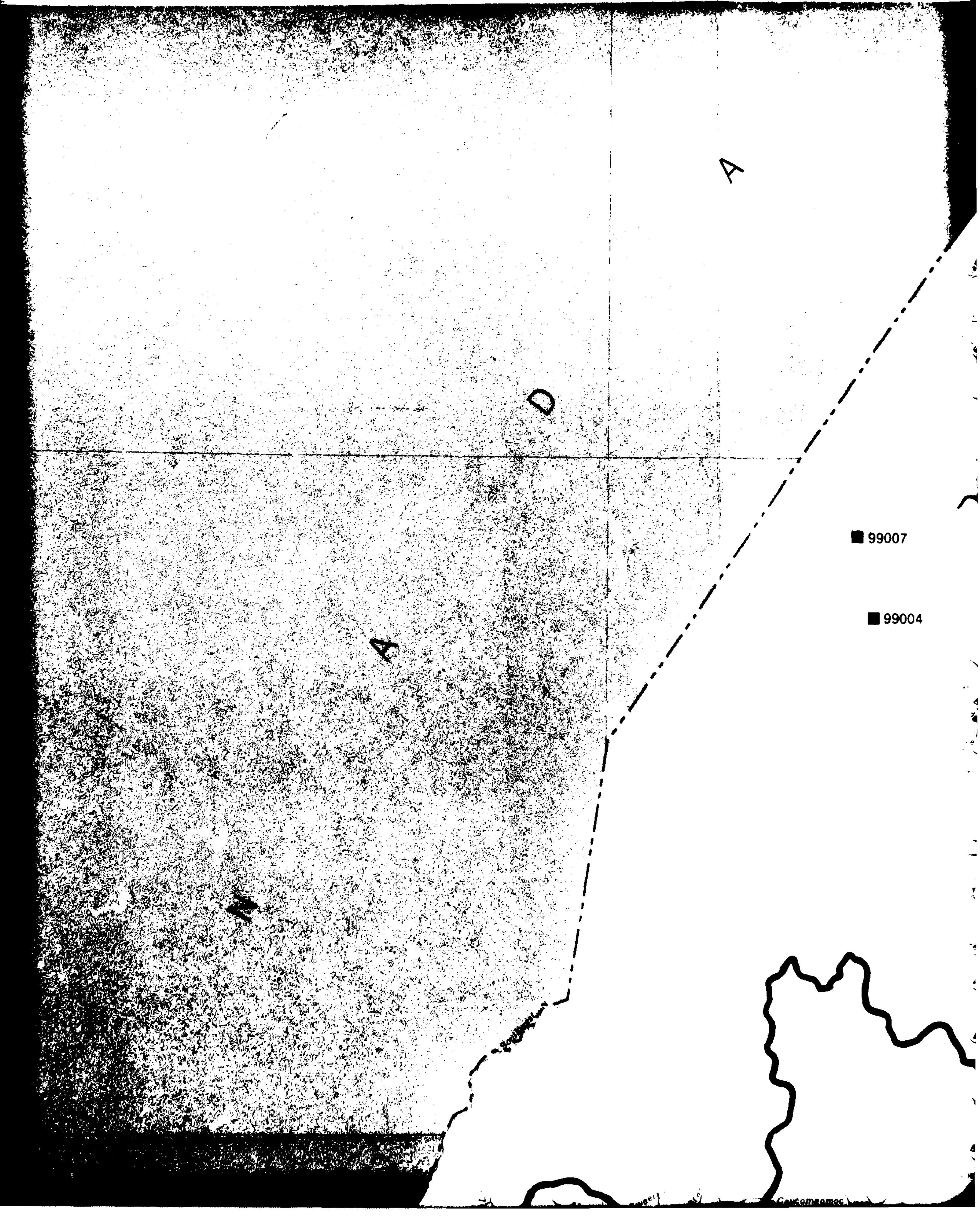
10 0 10 20

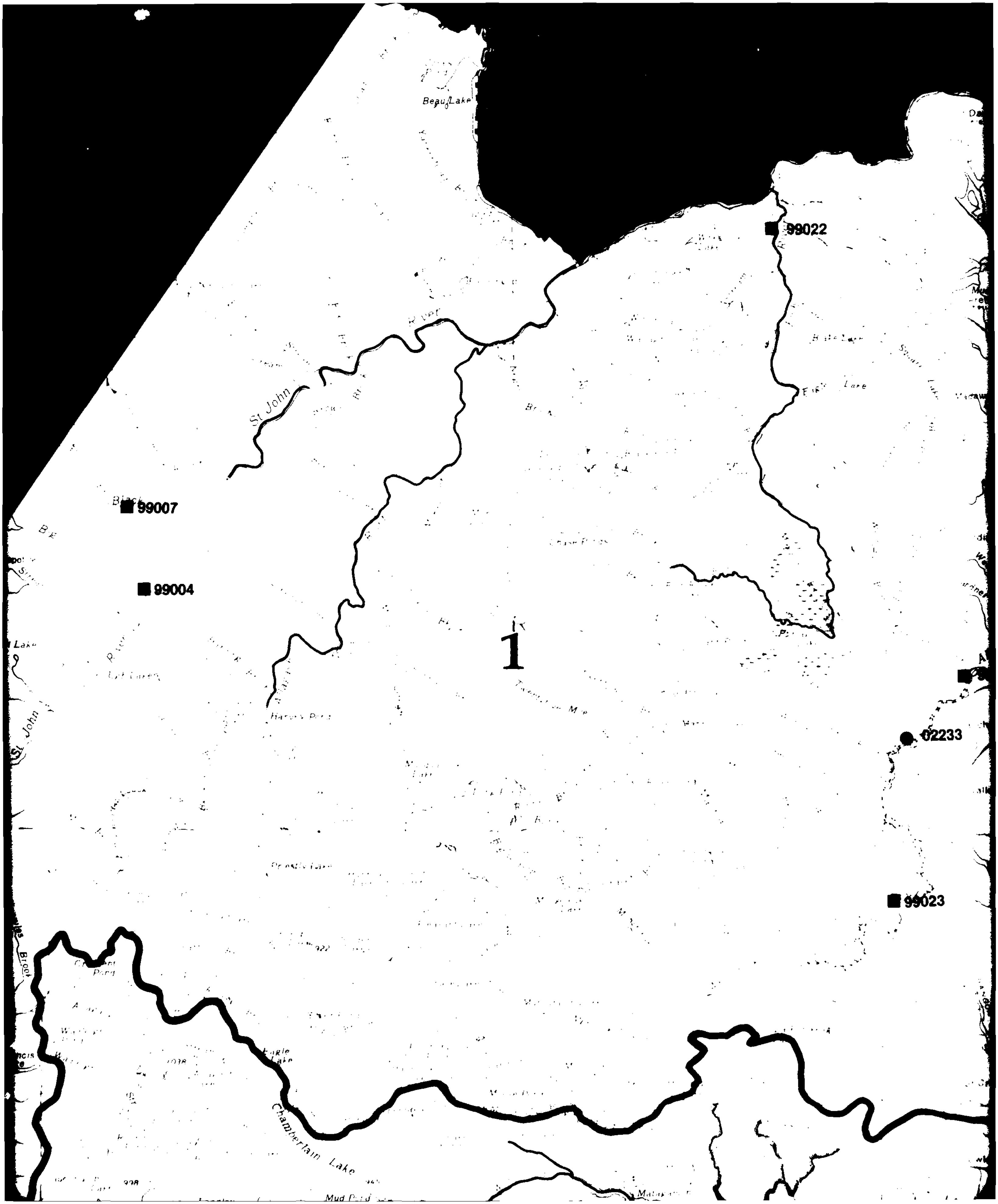
Miles

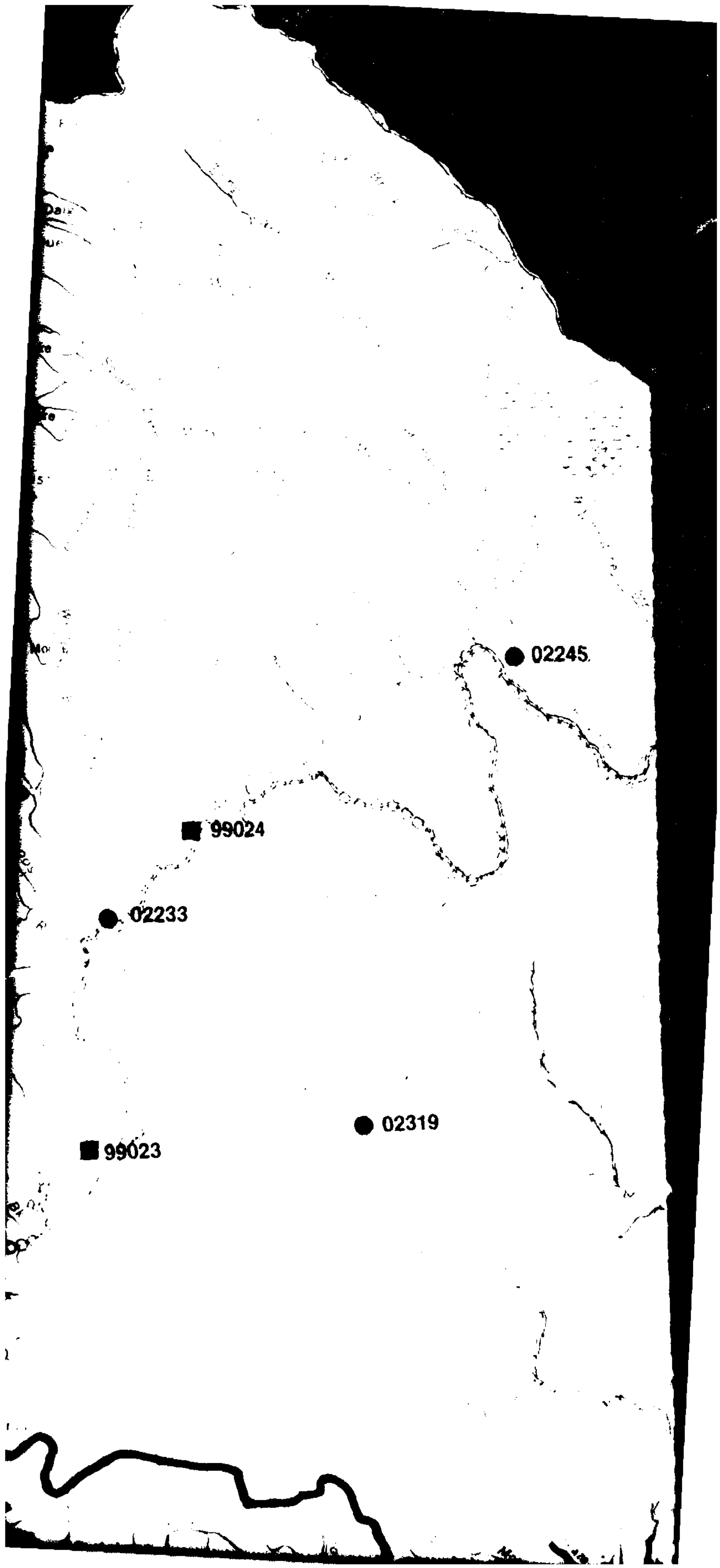
North

Scale: 1:500,000
1 inch equals approximately 8 miles.

Source: U.S.G.S., 1975


N A D A
99007
99004


Beau Lake
99022
St John River
99007
99004
1
02233
99023
Chamberlain Lake
Mud Pond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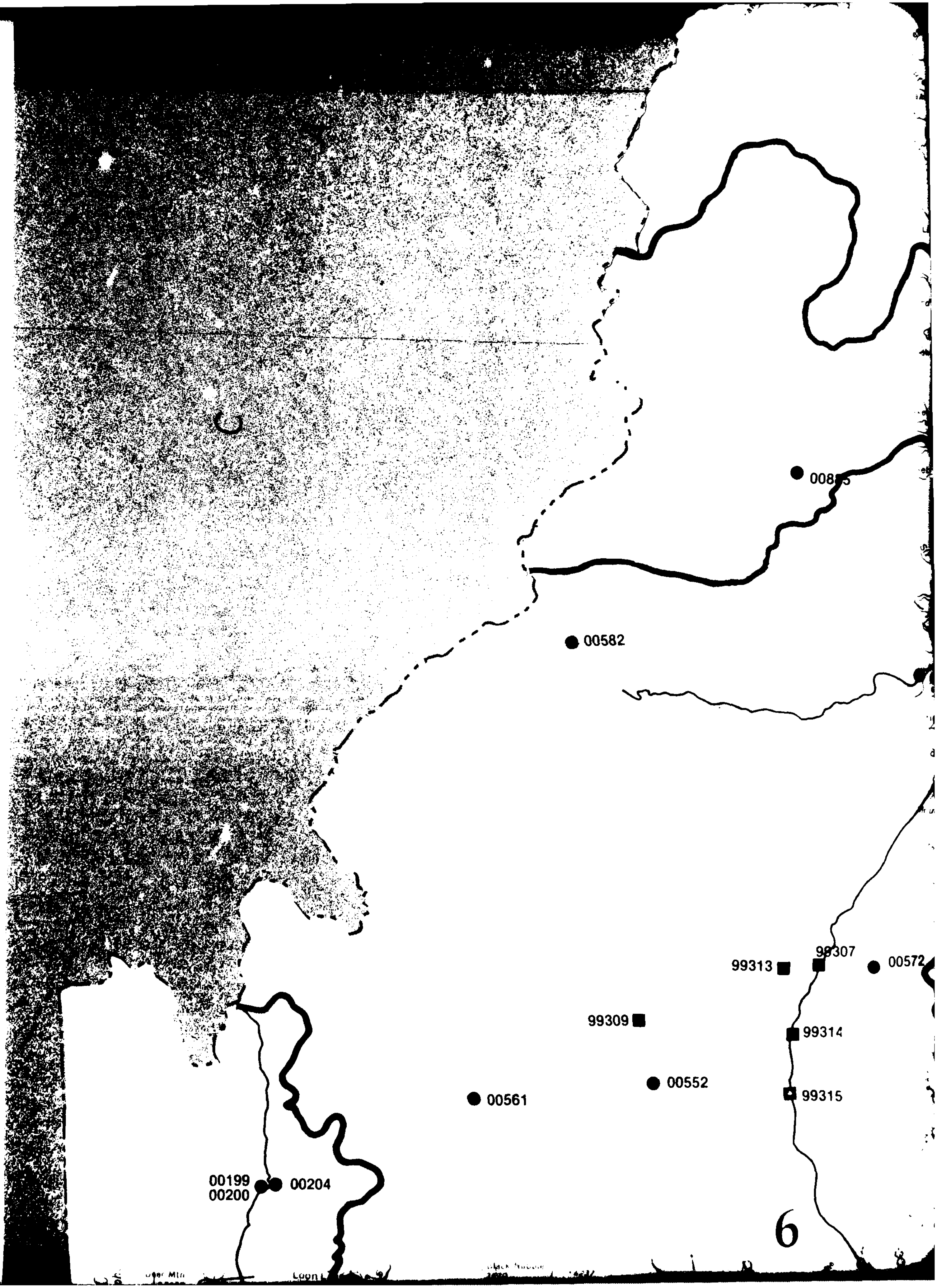
99024
02233
02319
99023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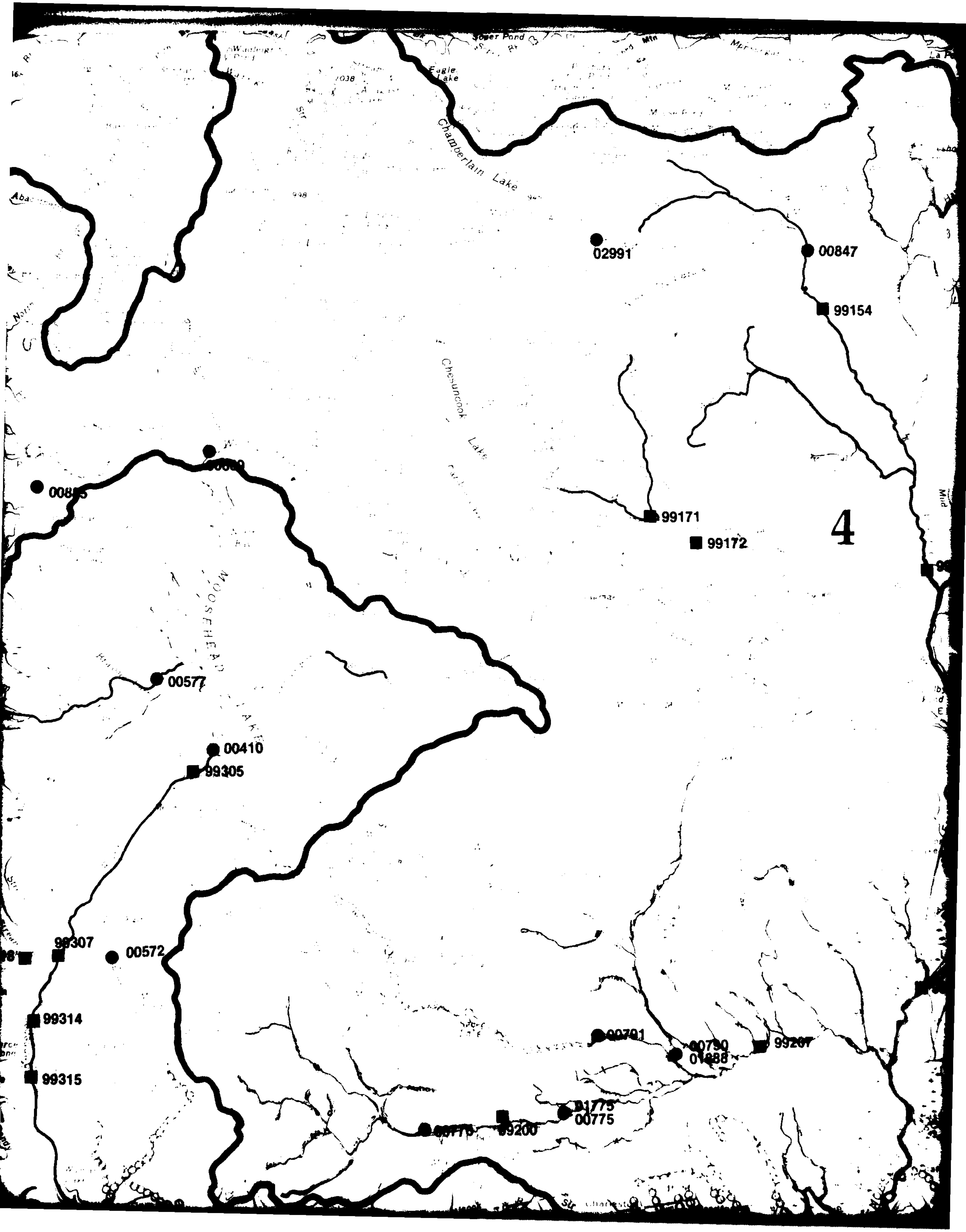
99313
00572
99309
99314
00552
99315
00561
00199
00200
00204
6



Chamberlain Lake
Eagle Lake
Chesuncook Lake
MOOSEHEAD LAKE
02991
00847
99154
99171
99172
4
00577
00410
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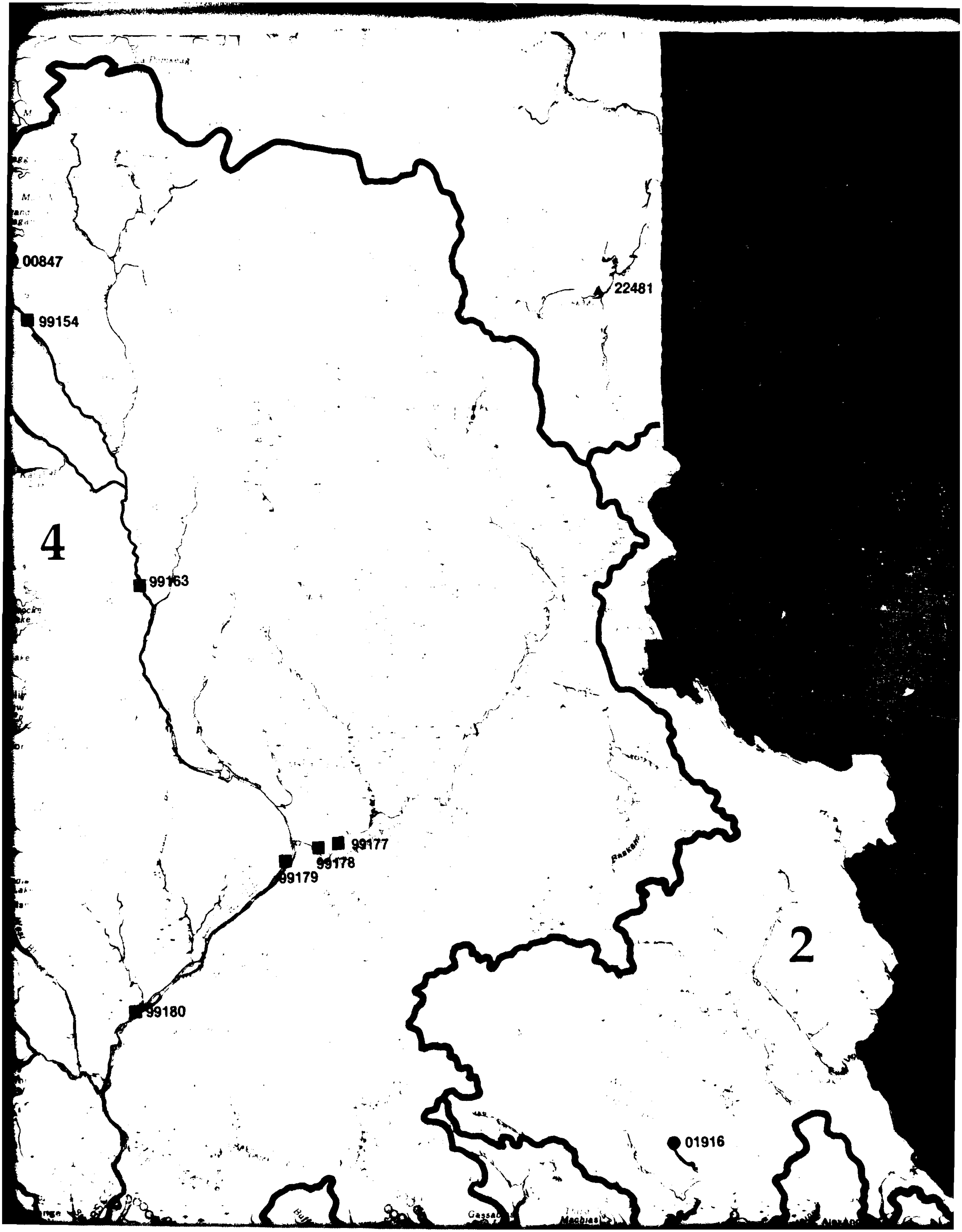
99307
00572
99314
99315
99200
00775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99178
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99180
2
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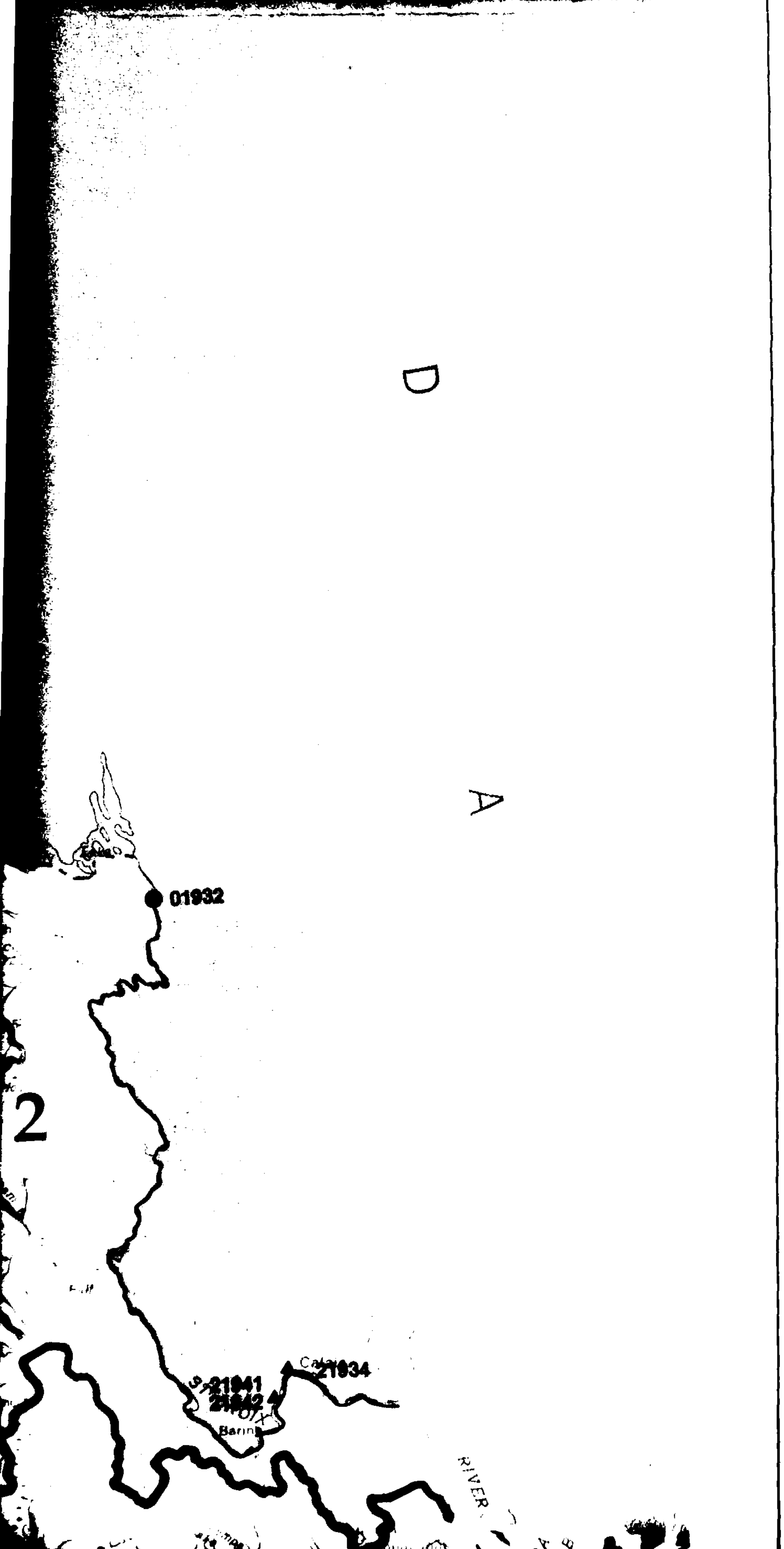
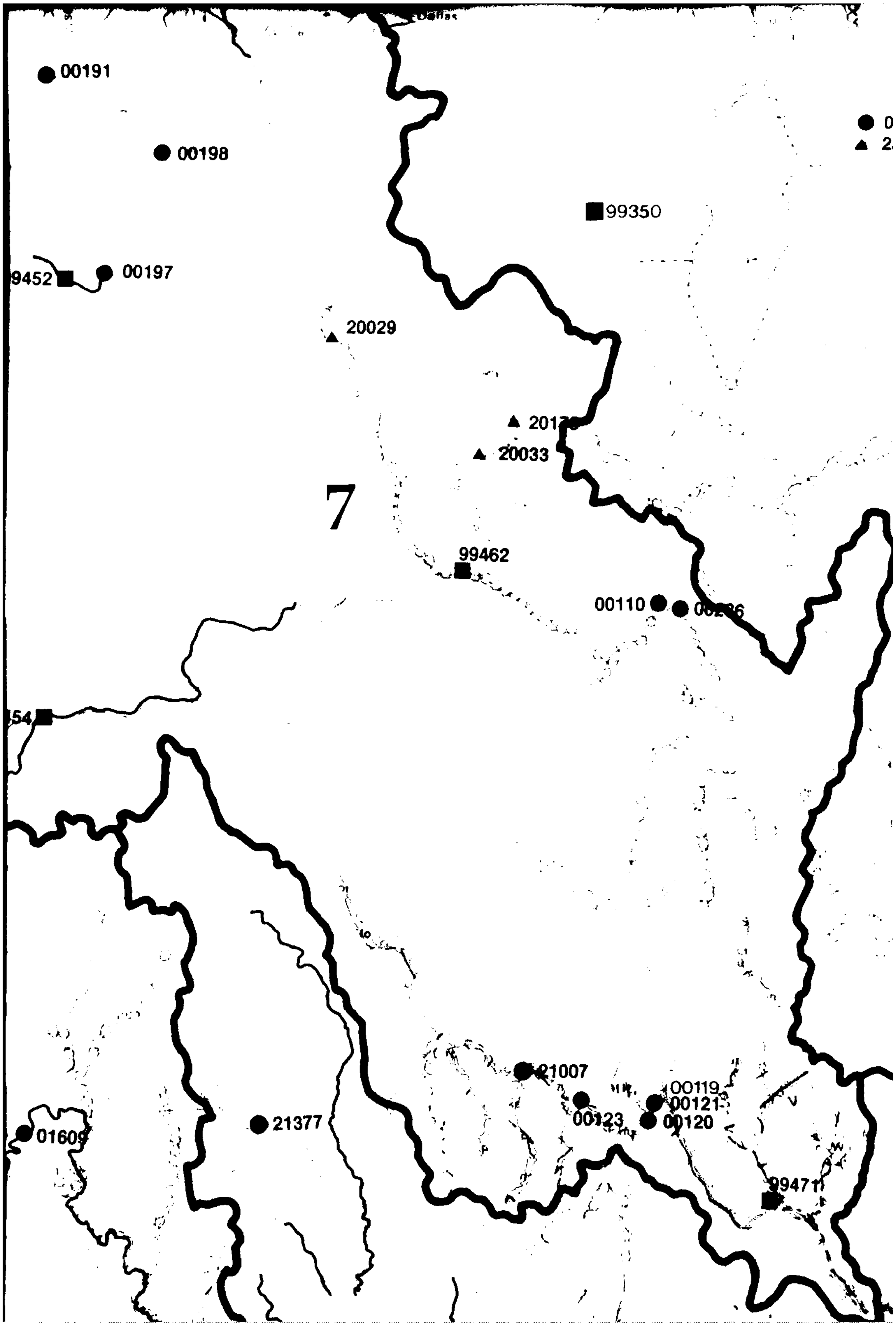


D
A
01932
2
21934
RIVER



00191
00198
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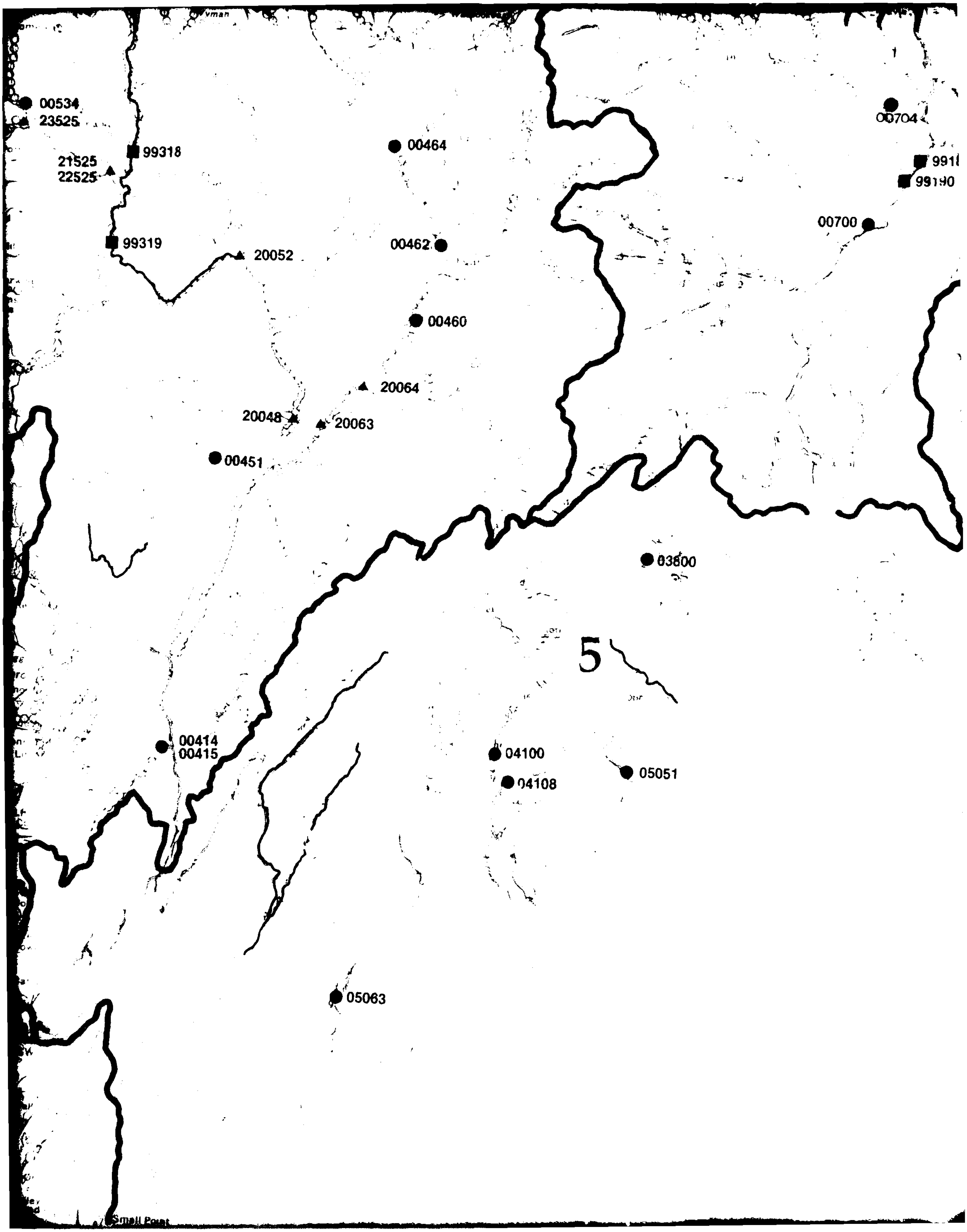
99471



00534
23525
99318
21525
22525
00464
00704
99190
00700
99319
20052
00462
00460
20064
20048
20063
00451
03800
5
00414
00415
04100
04108
05051
05063
Small Point

AD-A107 173 NEW ENGLAND RIVER BASINS COMMISSION BOSTON MA F/G 13/2
WATER, WATTS, AND WILDS HYDROPOWER AND COMPETING USES IN NEW EN--ETC(U)
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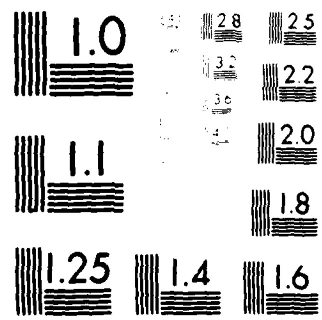
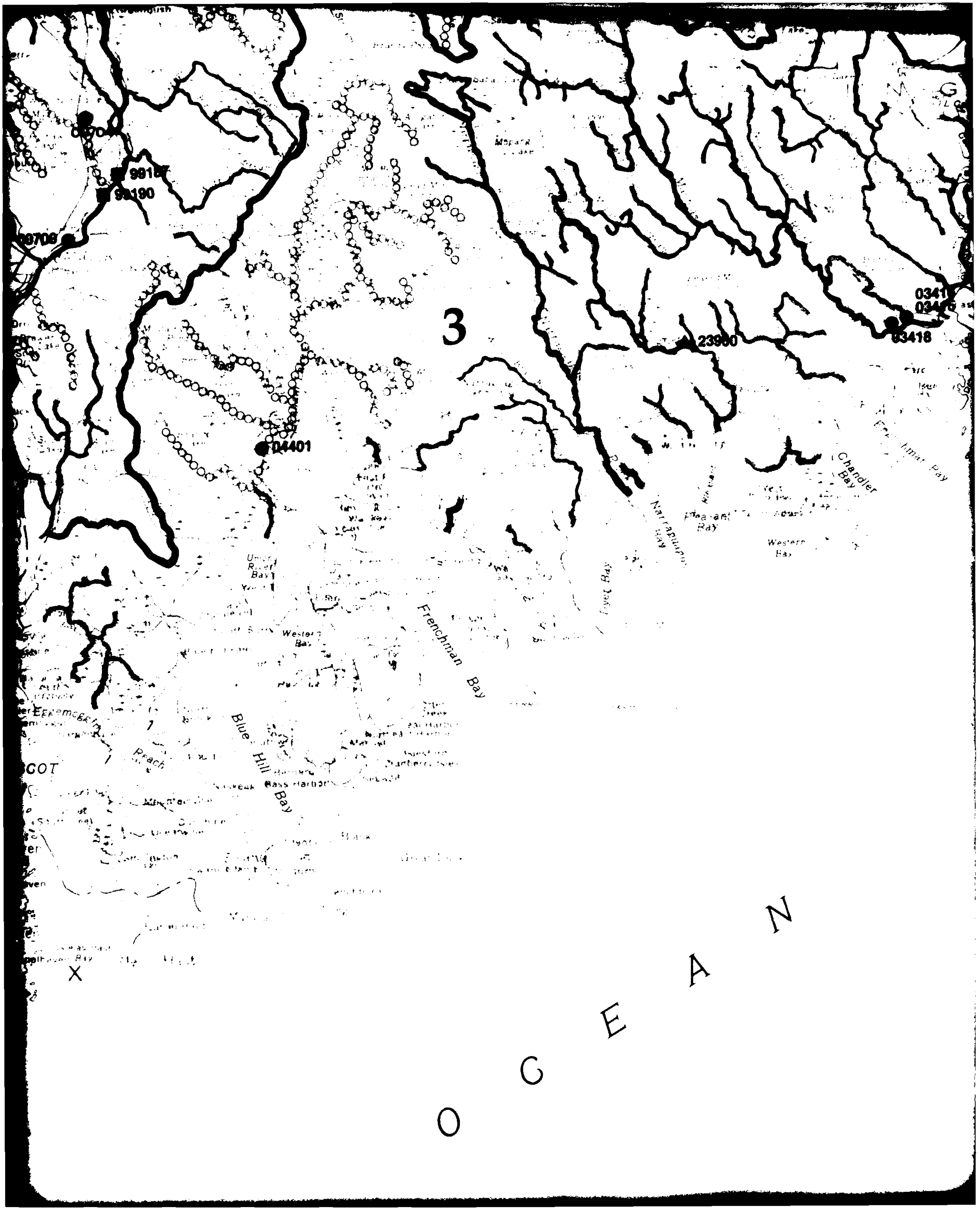
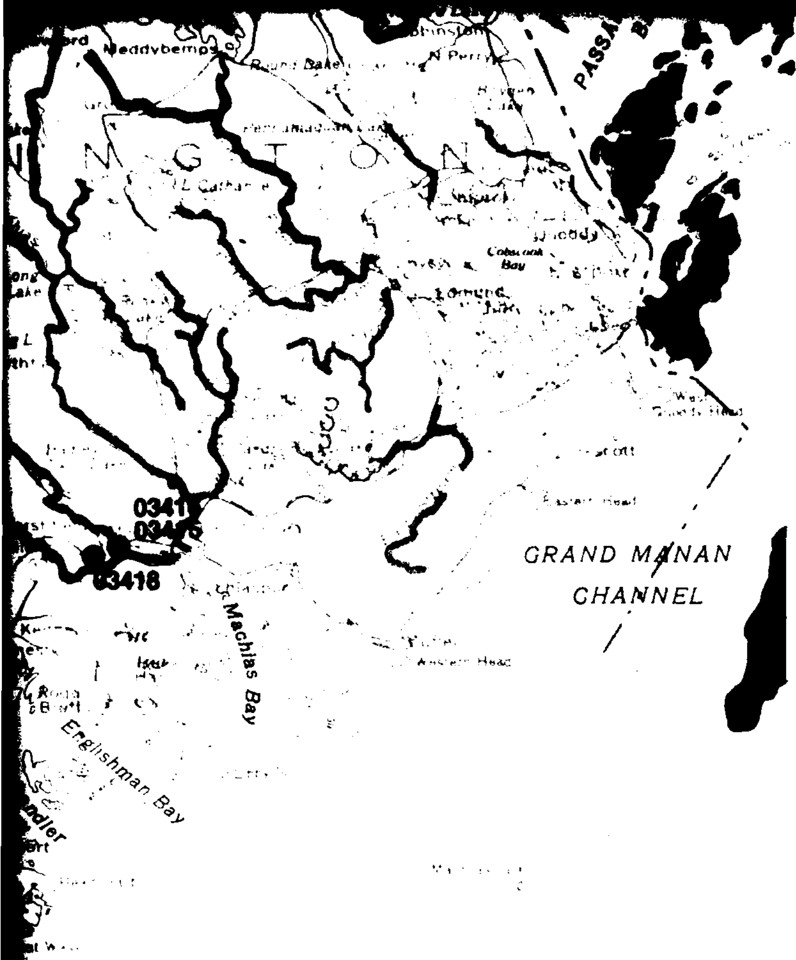
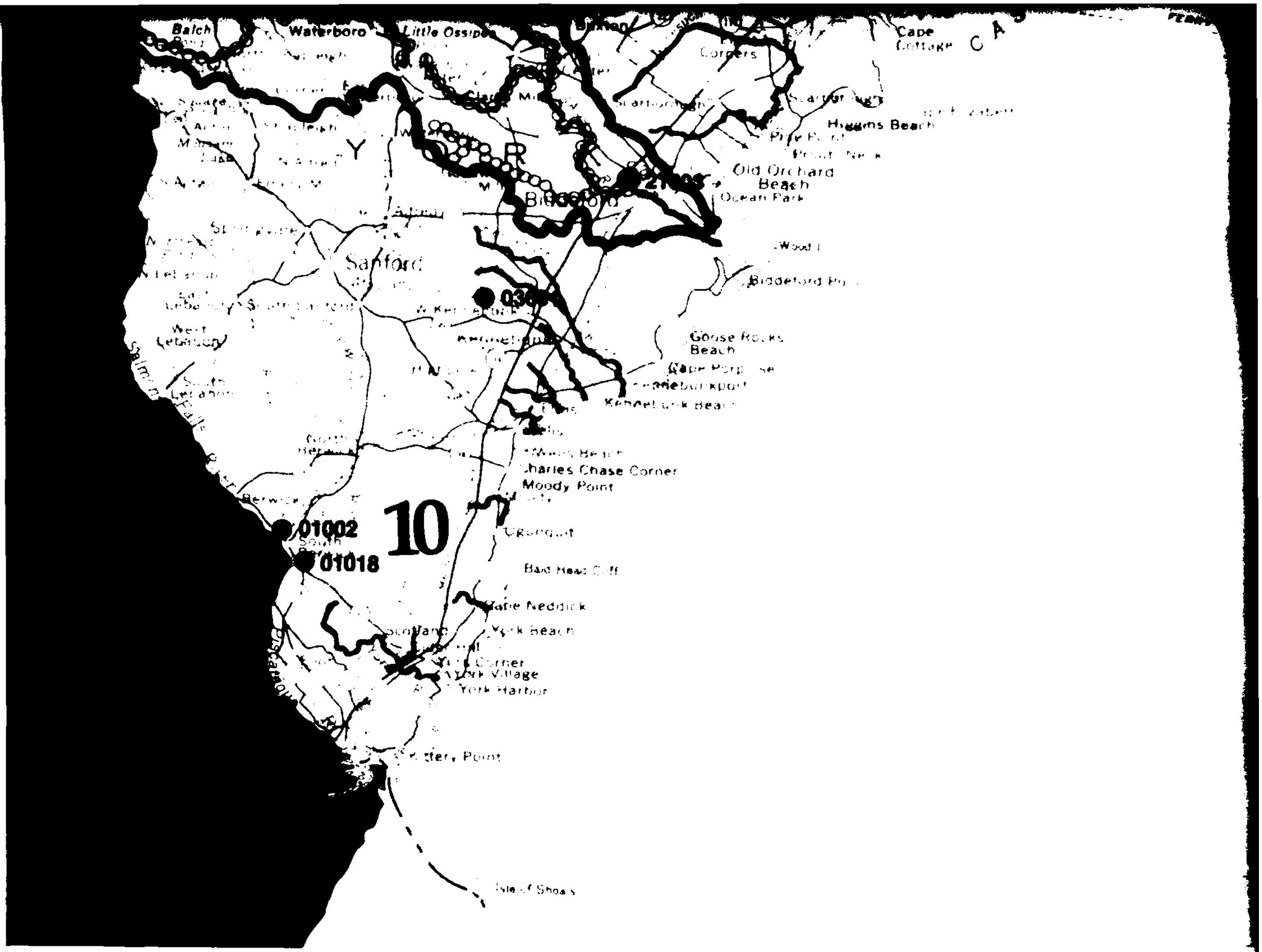


MICROCOPY RESOLUTION TEST CHART


3
04401
99190
09708
23980
03418
Frenchman Bay
Blue Hill Bay
Chandler Bay
Western Bay
Union River Bay
Reach
Bass Harbor
O C E A N


Meddybemps
Cobscook Bay
03418
GRAND MANAN
CHANNEL
Machias Bay
Englishman Bay



Potential Hydropower Sites:

●Existing dam
▲Breached dam
■Undeveloped site

Basin Boundary

Numerical Code

Code numbers refer to sites listed in Appendices A and B of the September 1981 report: *Water, Watts, and Wilds; Hydropower and Competing Uses in New England* and in Vols. III–VIII of the January 1980 report: *Potential for Hydropower Development at Existing Dams in New England*, both published by the New England River Basins Commission.

Basis of Site Selection

Sites shown are sites from the NERBC economic feasibility analysis which have estimated energy costs less than or equal to the following:

Existing and breached dams: $.125/kwh
Undeveloped sites: $.115/kwh

For purposes of the feasibility analysis, an interest rate of 15% and a plant factor of 70% were assumed. Transmission line or environmental mitigation costs were not included. Flood control dams constructed by the U.S. Army Corps of Engineers are not included on the map.

Index to River Basins

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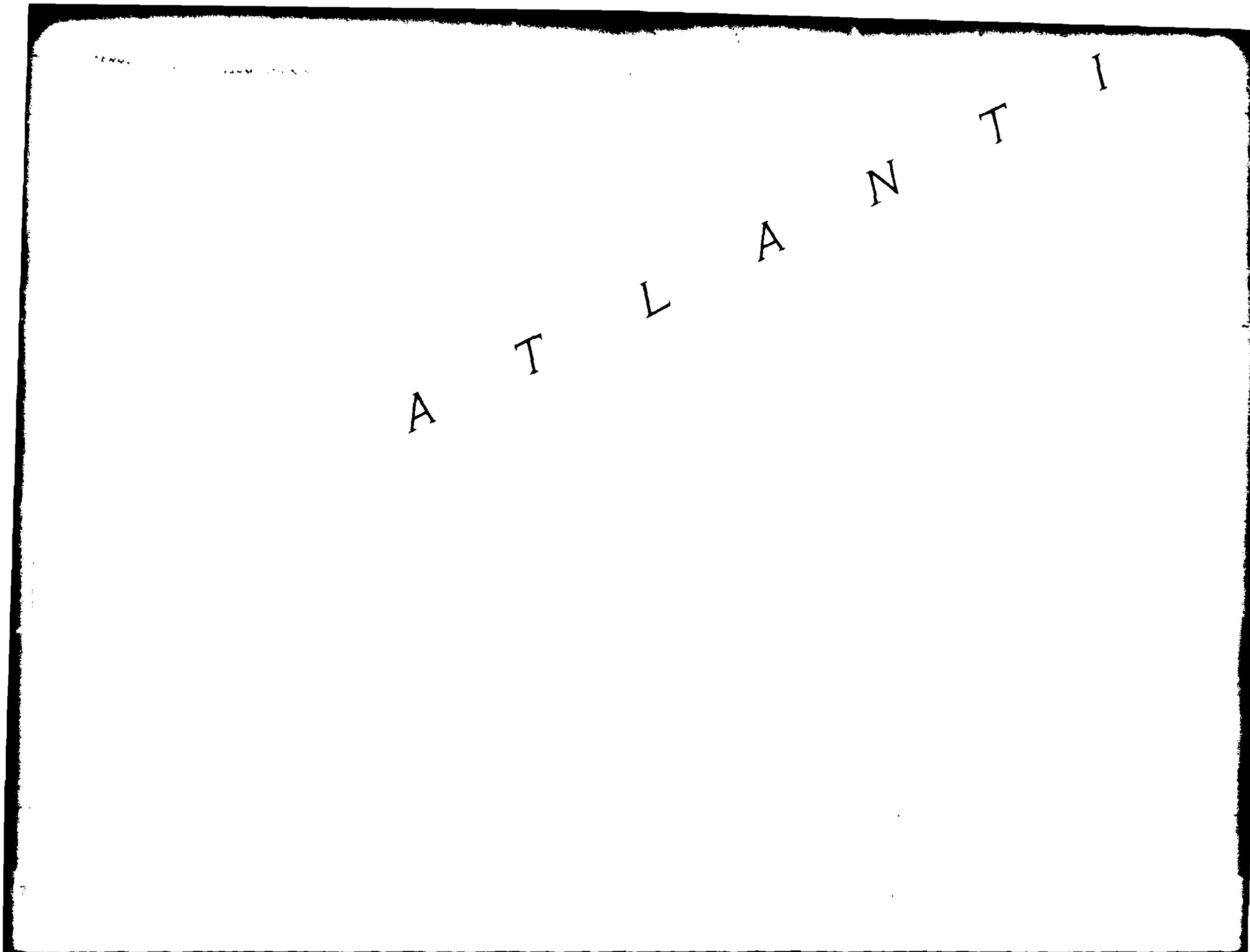


2 Fishery Reso

Anadromous Fish Runs

Existing

Currently under active restoration

Potential with inaccessible habitat

Freshwater Fish

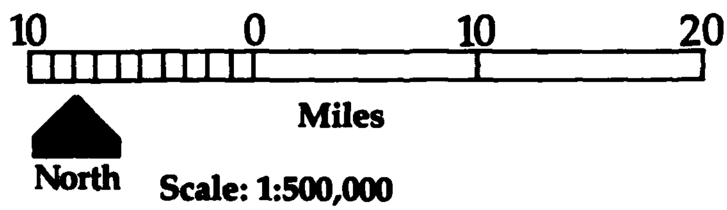
Important cold water fisheries

Data Source:

Appendix D of ***Water, Watts, and Wilds; Hydropower and Competing Uses in New England***

Hydropower Program
New England
River Basins Commission

September, 1981



Scale: 1:500,000
1 inch equals approximately 8 miles

Source: U.S.G.S., 1975